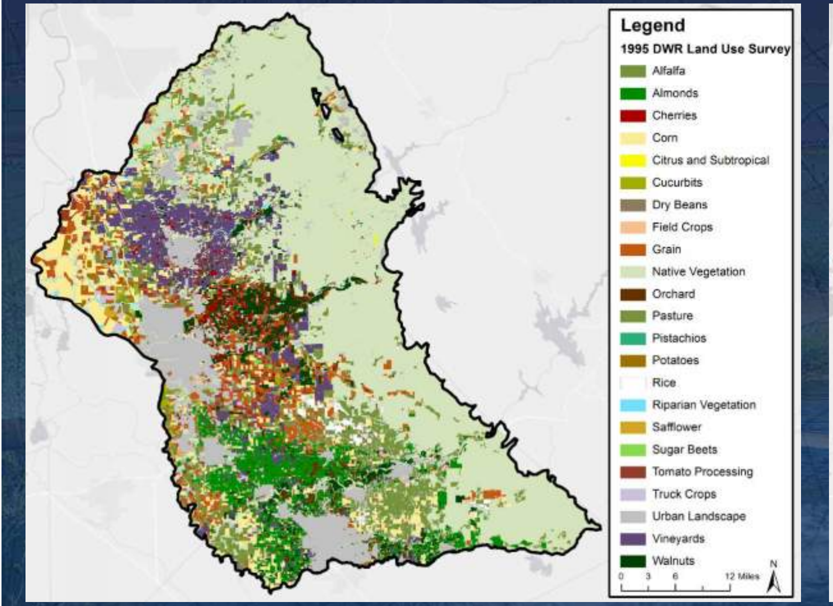
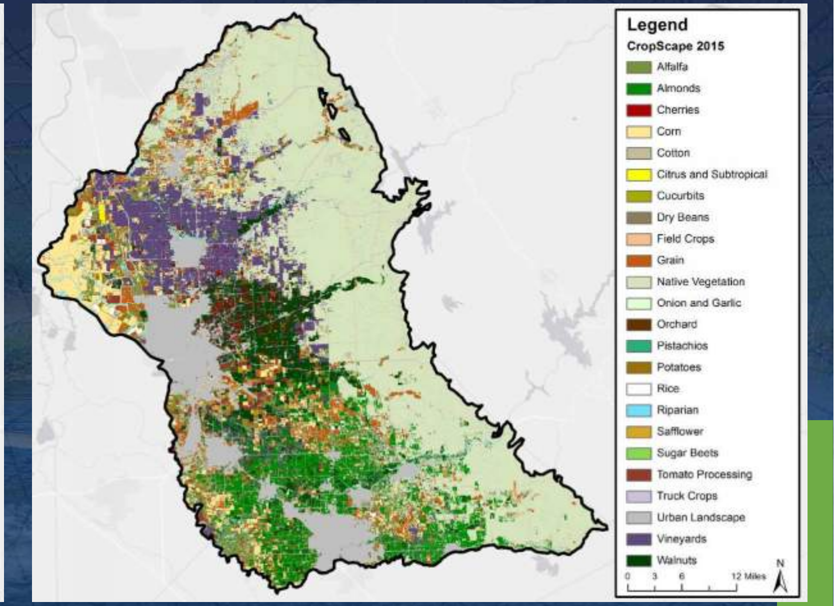
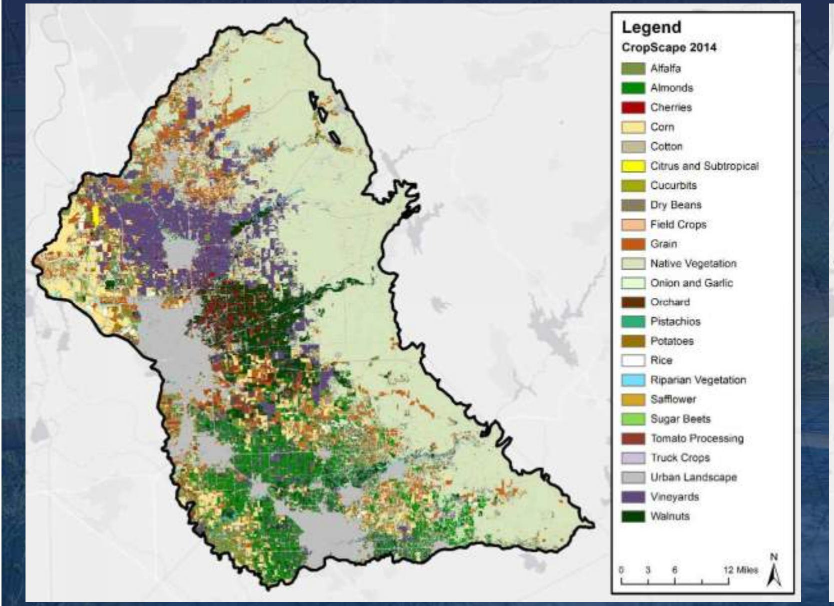
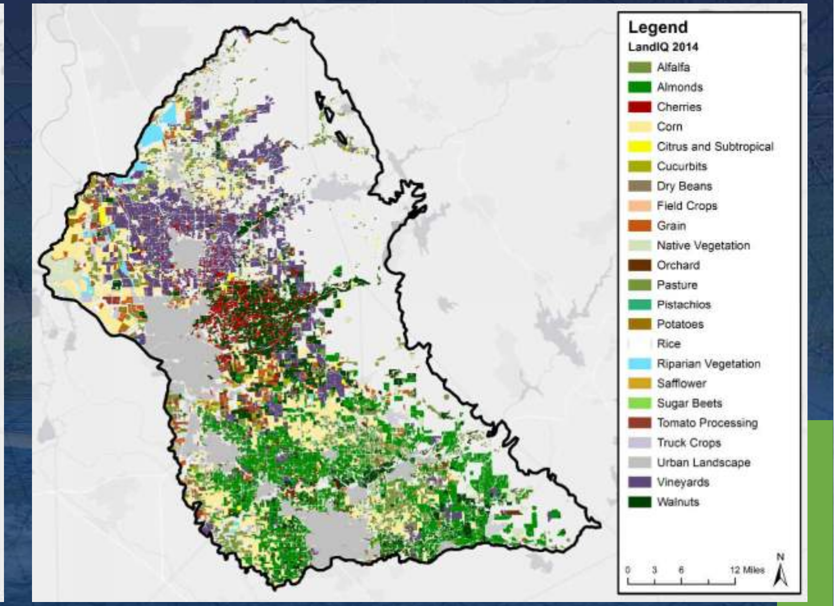
ESJ Model Area Cropping Pattern (1995 & 2015)



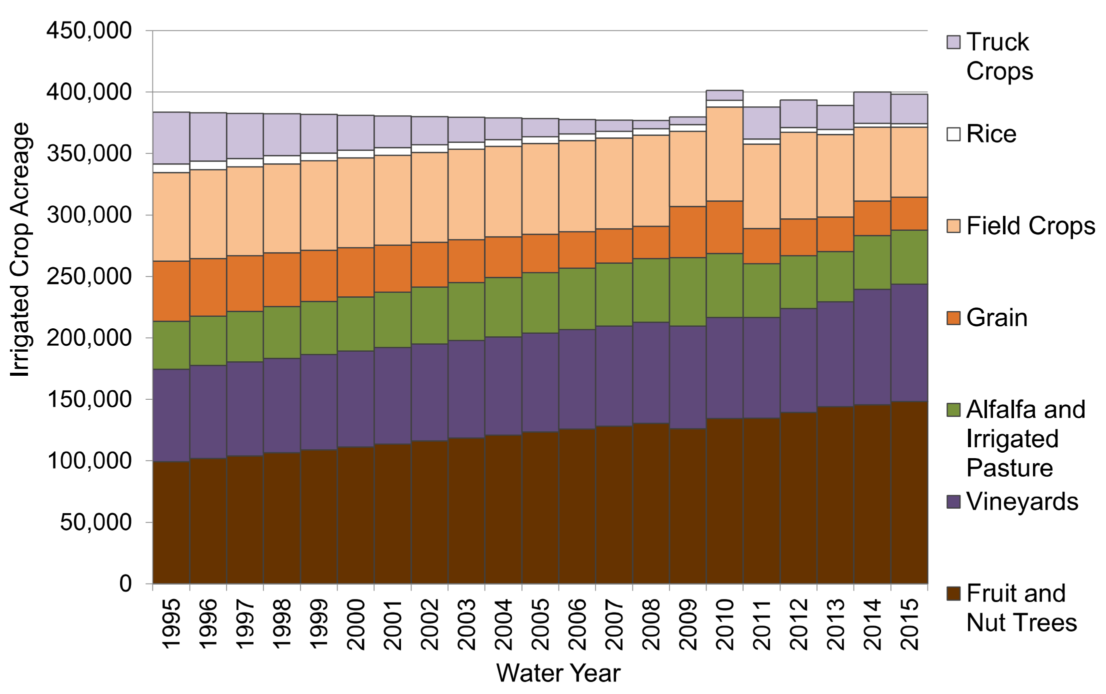


2014 Cropping Pattern (CropScape & LandIQ)

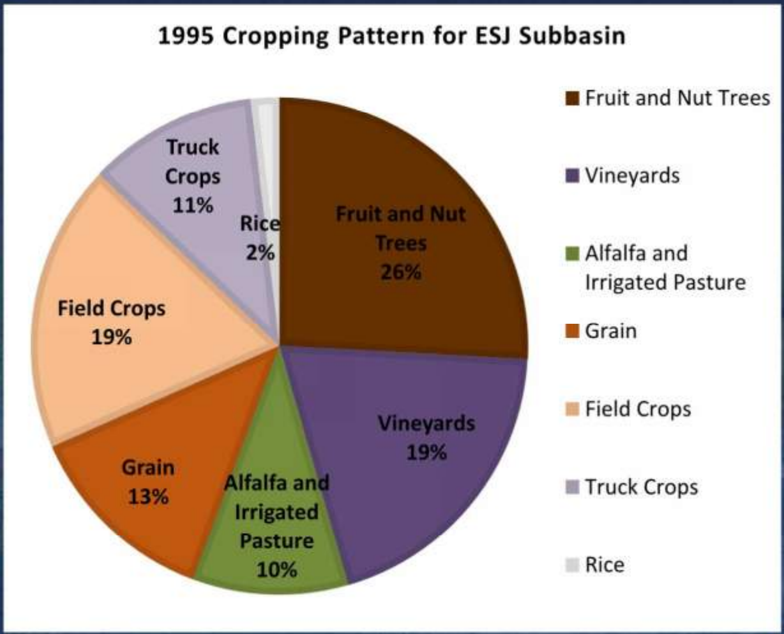


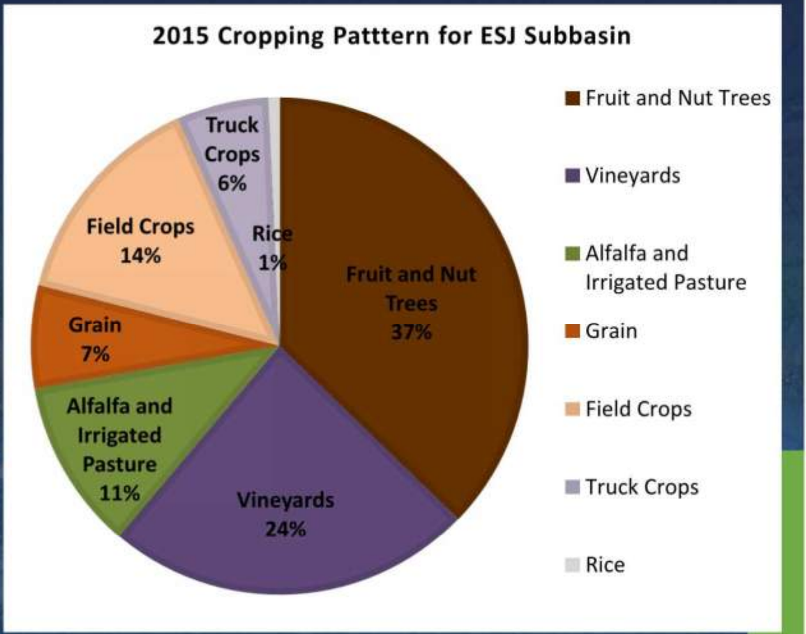


Primary Cropping Pattern in ESJ Subbasin

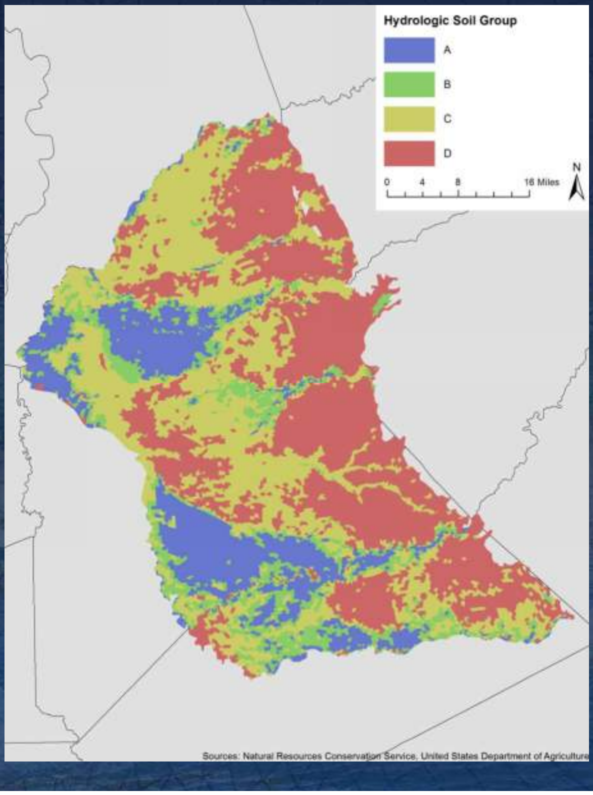


Primary Cropping Pattern in ESJ Subbasin


1995 Cropping Pattern for ESJ Subbasin


2015 Cropping Patttern for ESJ Subbasin

Root Zone Parameters

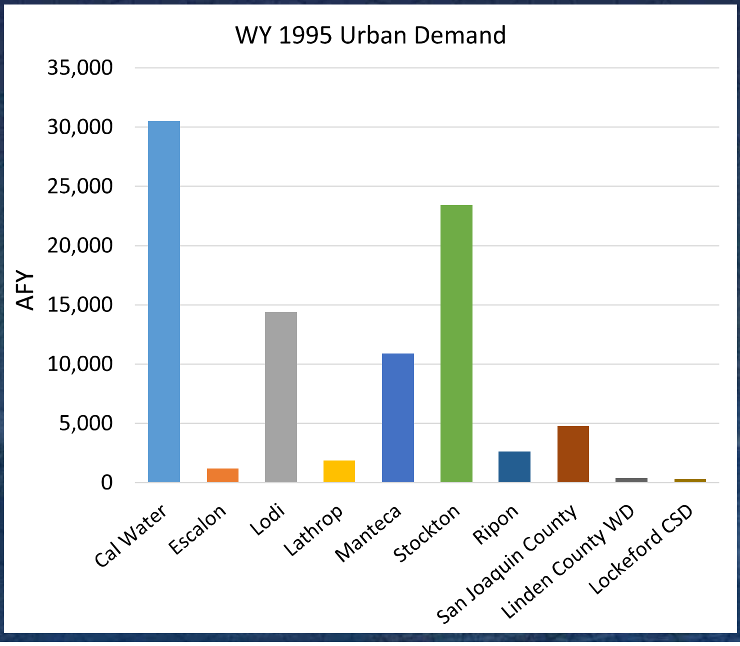


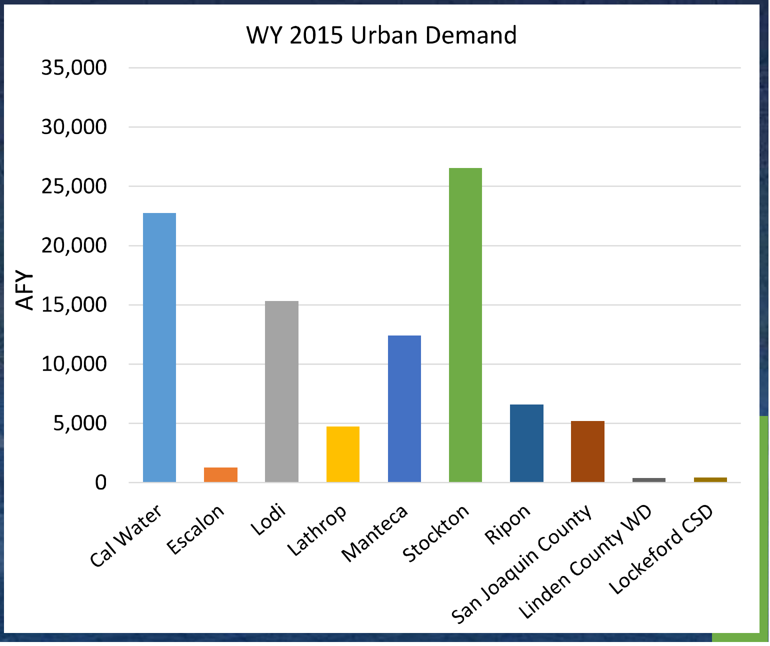
Sources: Natural Resources Conservation Service, United States Department of Agriculture

---

Urban Water Demand

- Based on GPCD and population if water demand information unavailable





Land & Water Use Budget Components

Cropping Pattern & Irrigation Practices

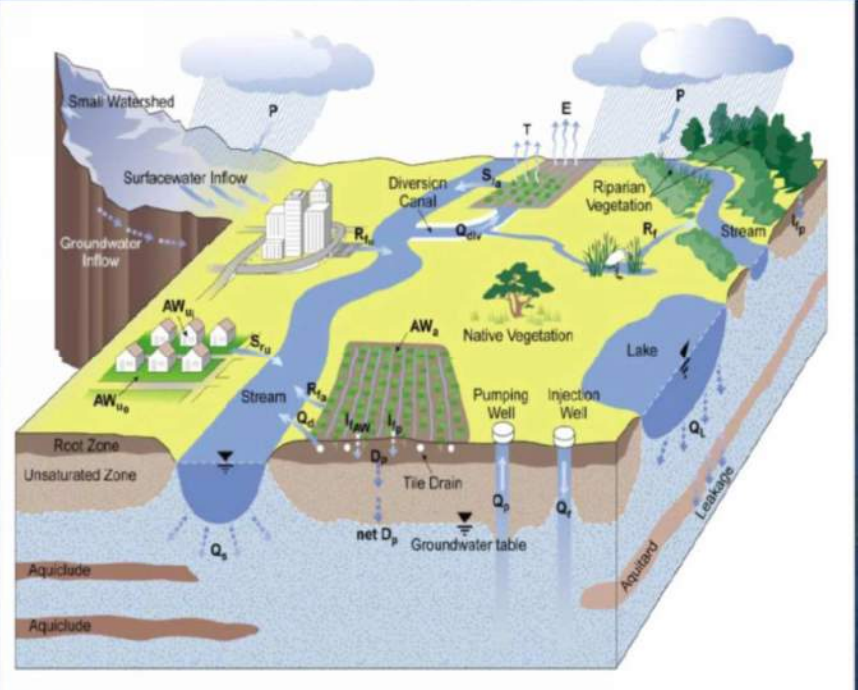
Rainfall

Water Supply Data

Land & Water Use Budget

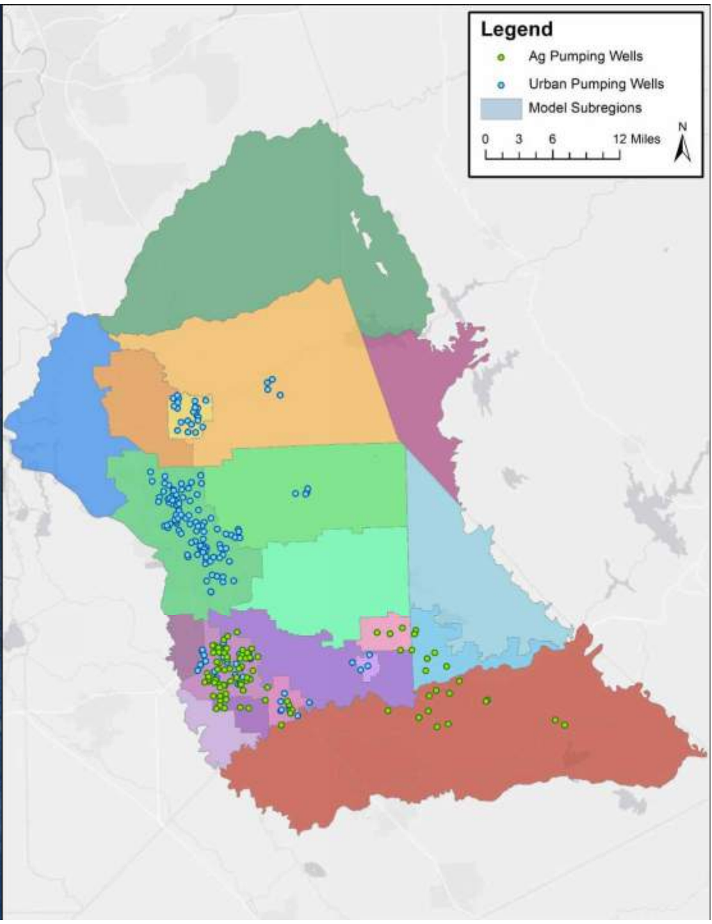
Integrated Hydrologic Processes

- Land Surface Processes
- Groundwater Flow
- Streamflow
- Physical Systems Integration
- Water Budgets



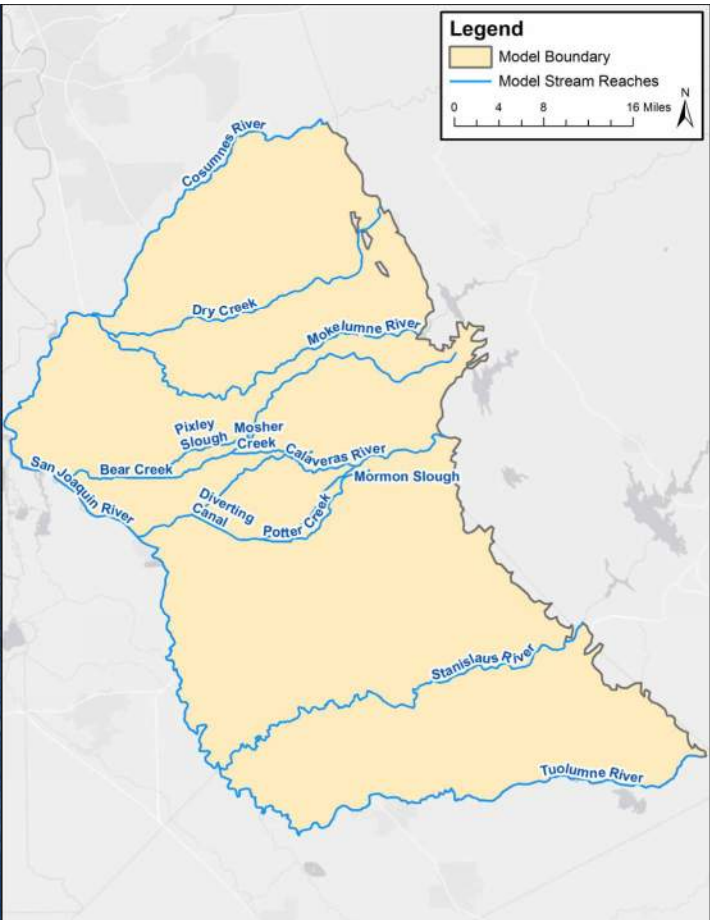
Water Supply Data Sources

- Groundwater pumping for ag or urban purposes:
  - Cal Water
  - Escalon
  - Lathrop
  - Linden County
  - Lockeford CSD
  - Lodi
  - Manteca
  - Oakdale ID
  - Ripon
  - Stockton East WD
  - South San Joaquin ID
  - Stockton



Water Supply Data Sources

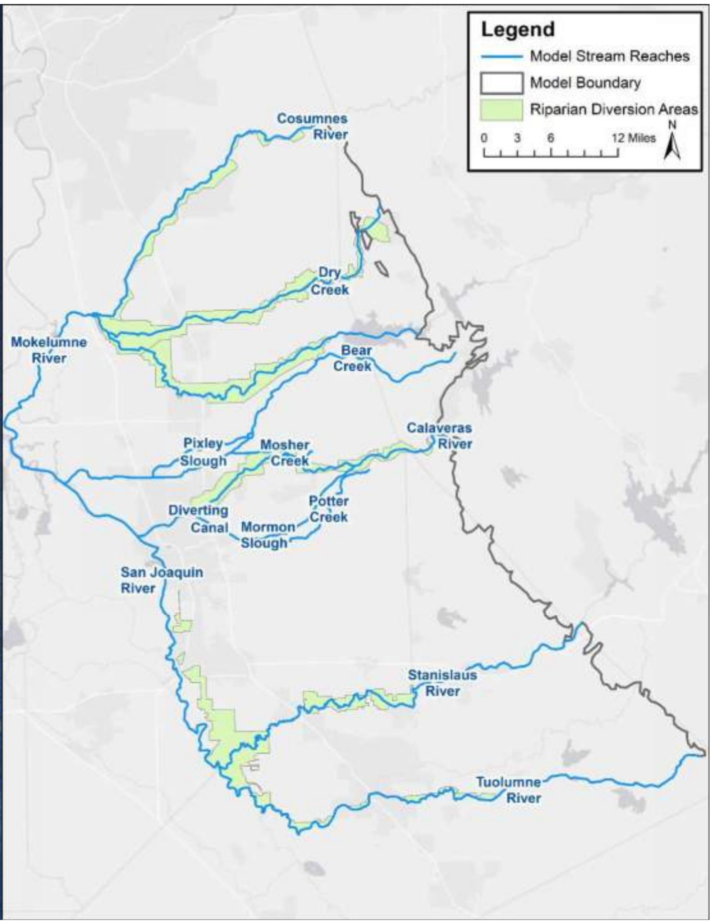
- Surface water deliveries for ag or urban purposes:
  - North Delta
  - Woodbridge ID
  - Lodi
  - North San Joaquin WCD
  - Calaveras County WD
  - Stockton/Cal Water
  - Stockton East WD
  - Central San Joaquin WCD
  - Lathrop
  - Manteca
  - Escalon
  - South San Joaquin ID
  - Oakdale ID
  - Modesto ID/Modesto
  - Riparian



Riparian Diversions

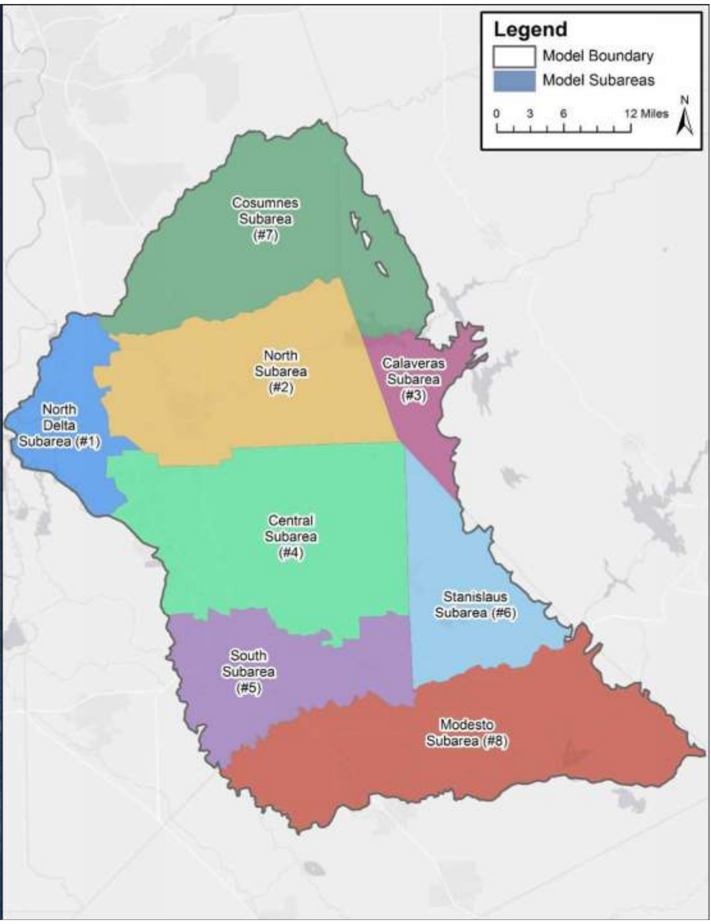
- Accounts for non-district SW users with access to streams
- From C2VSim-2015
  - Recoverable Loss: 10-15%
  - Non-recoverable Loss: 2-3%
- Delivery areas pers. comm. Charlie Brush (DWR)

Stream	Annual Average (AFY)
Cosumnes River	4,283
Dry Creek	6,026
Mokelumne River	9,724
Calaveras River	20,356
Stanislaus River	20,705
Tuolumne River	2,547
San Joaquin River	6,210

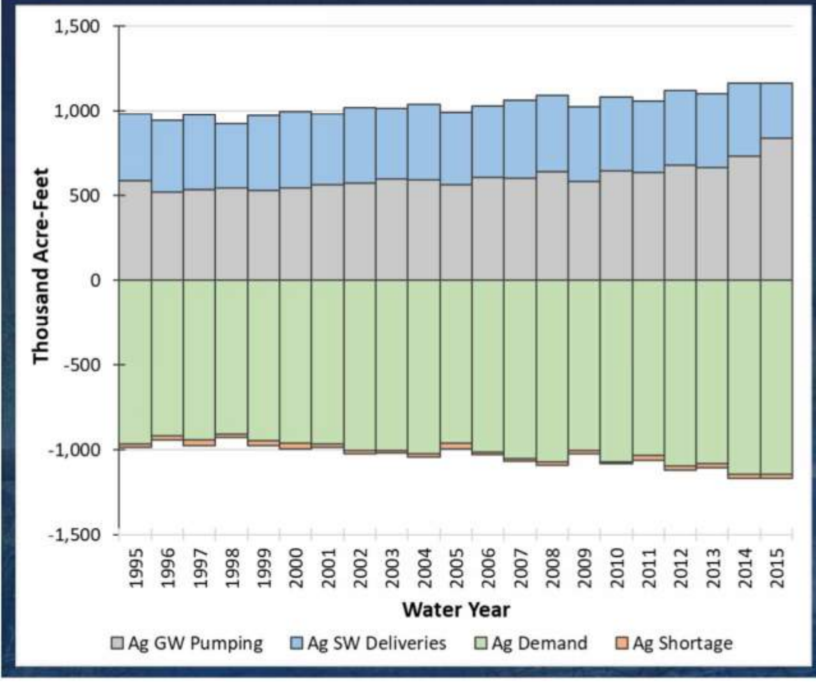


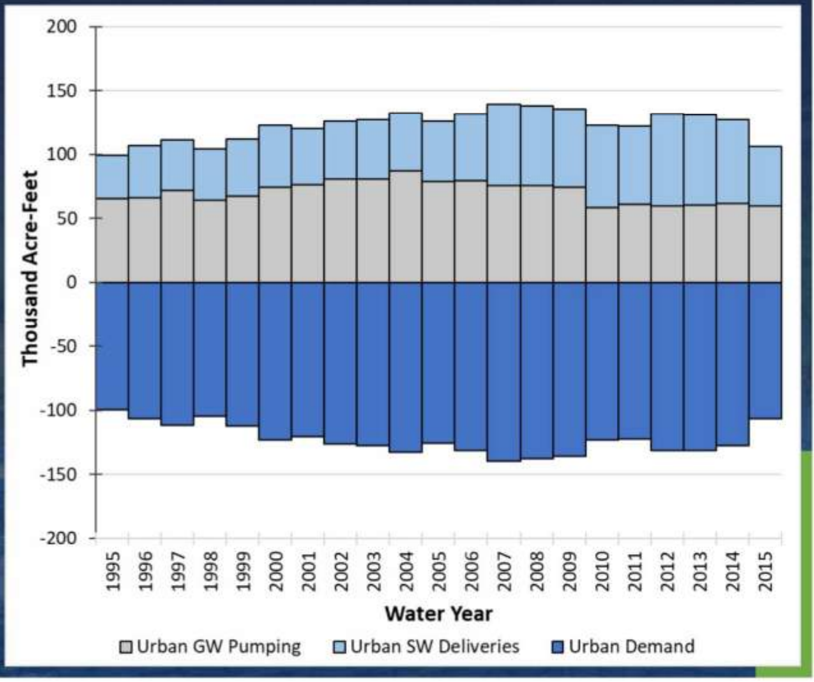
Model Subareas

- 8 subareas
- For model output and reporting of results

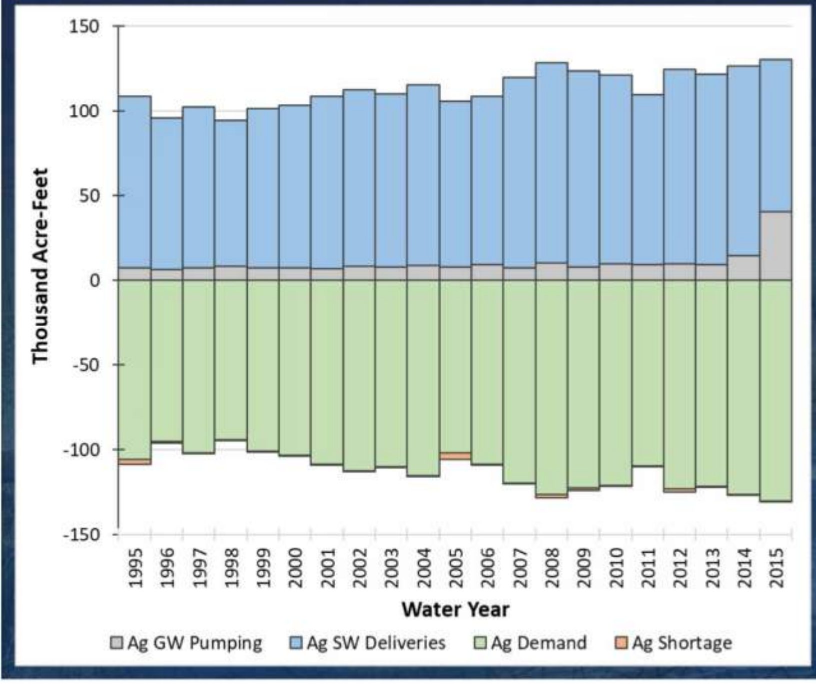


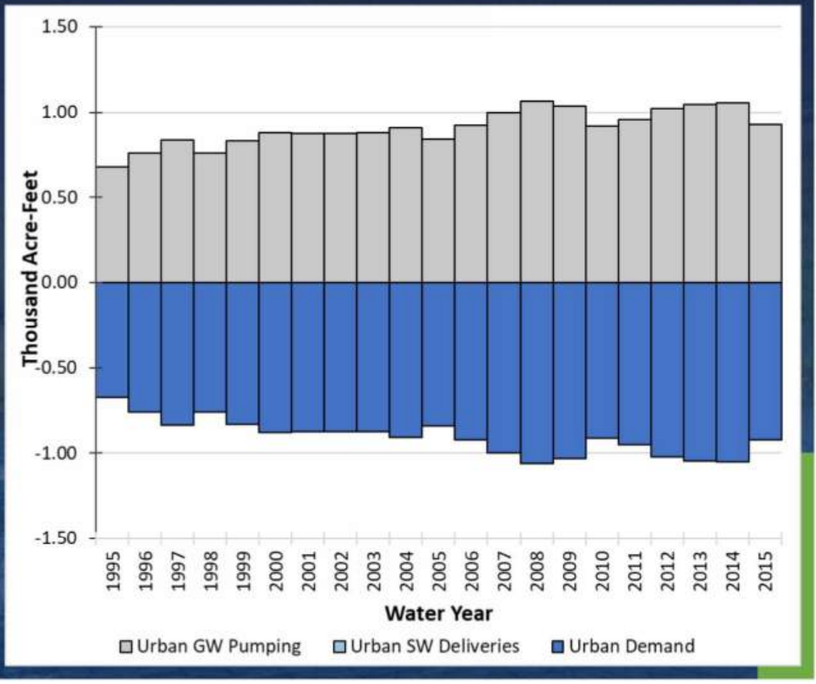
L&WU Budget- ESJ Subbasin



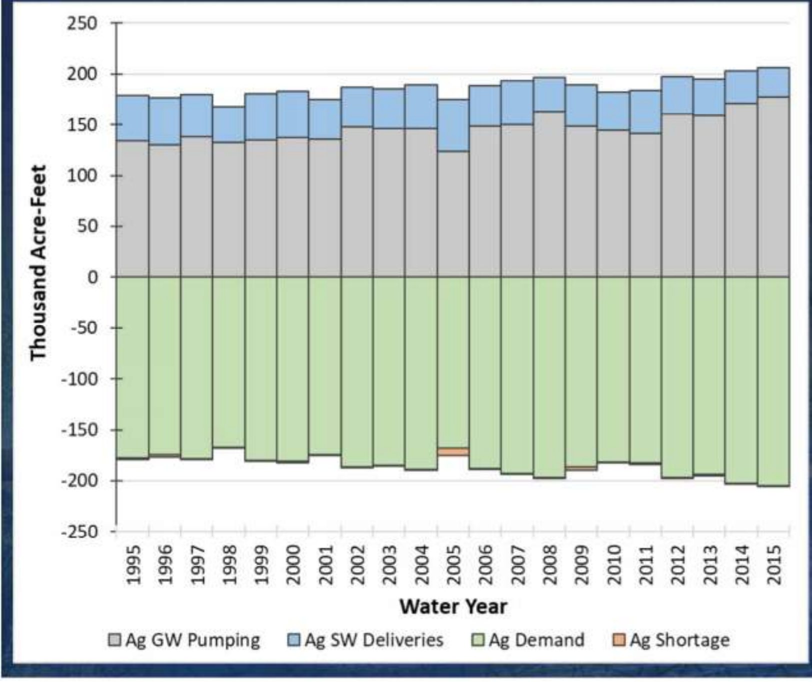


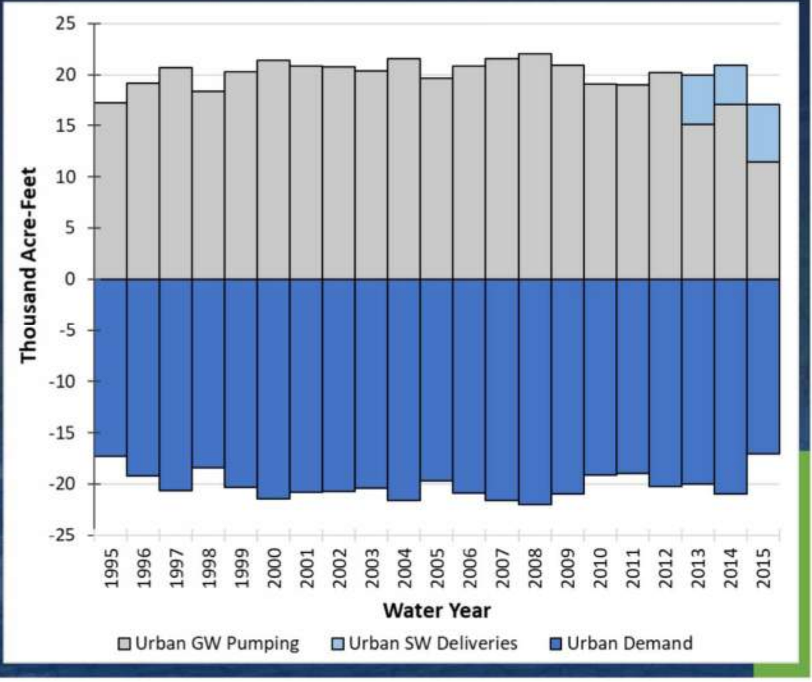
North Delta Subarea



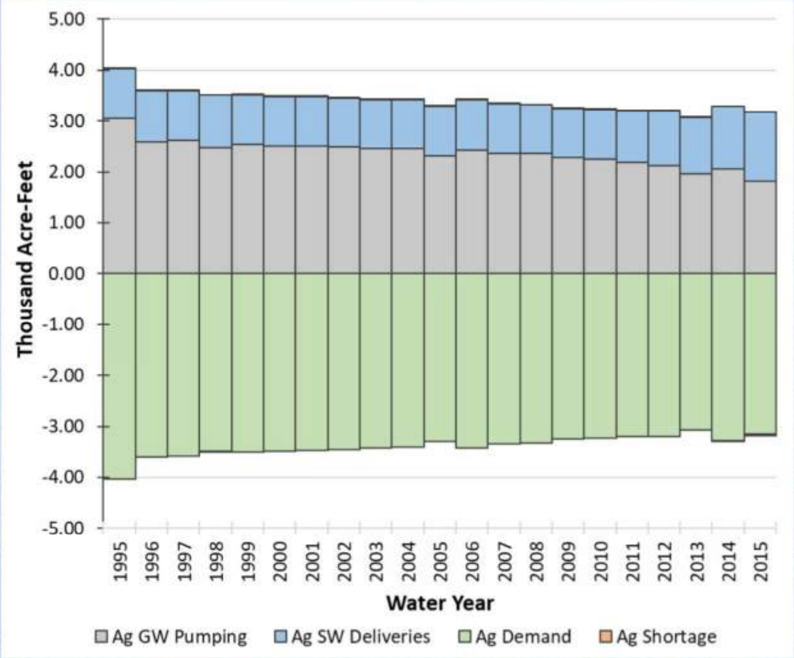


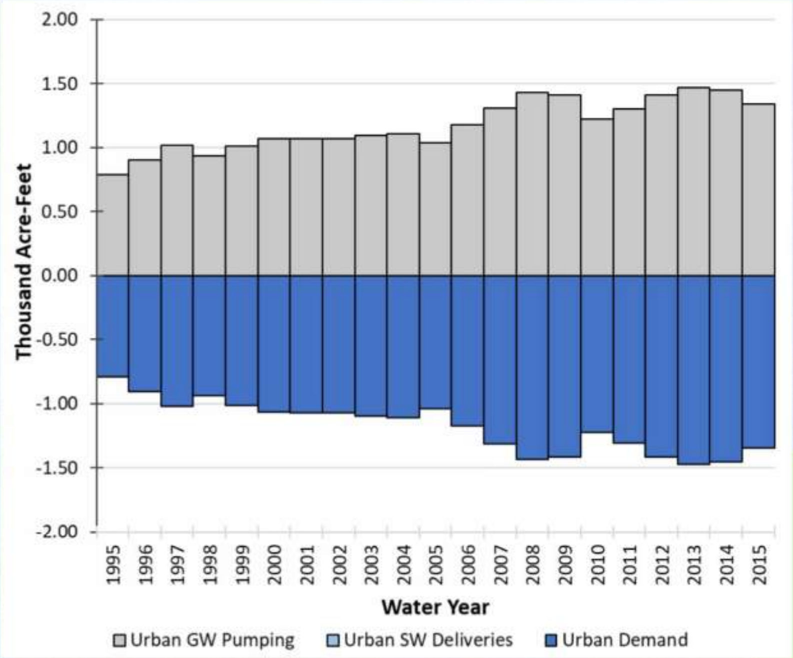
North Subarea



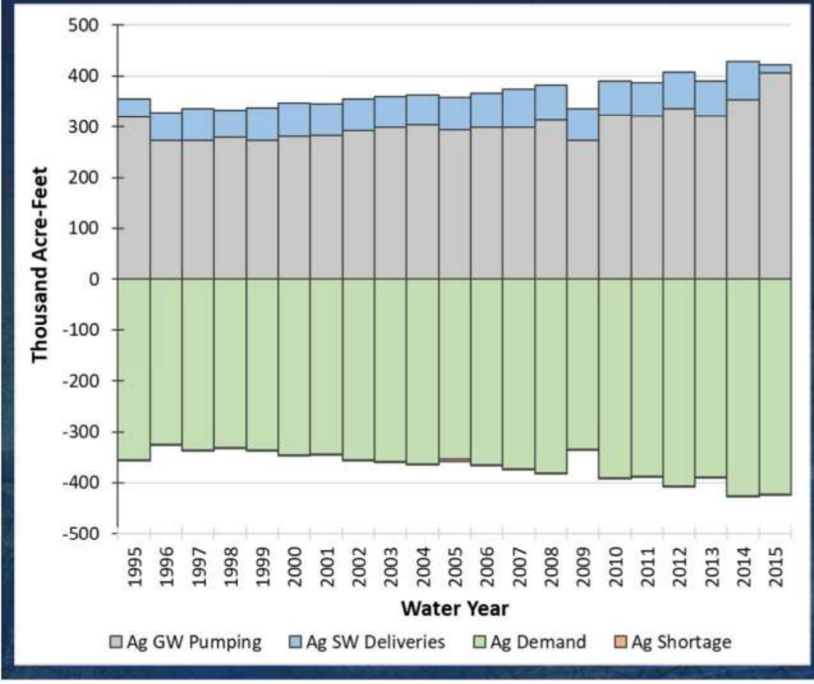


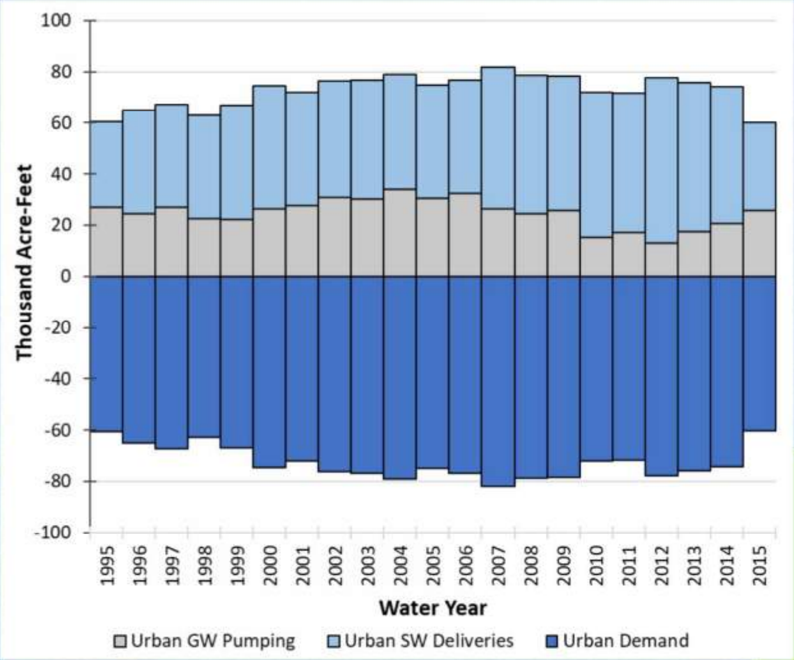
Calaveras Subarea



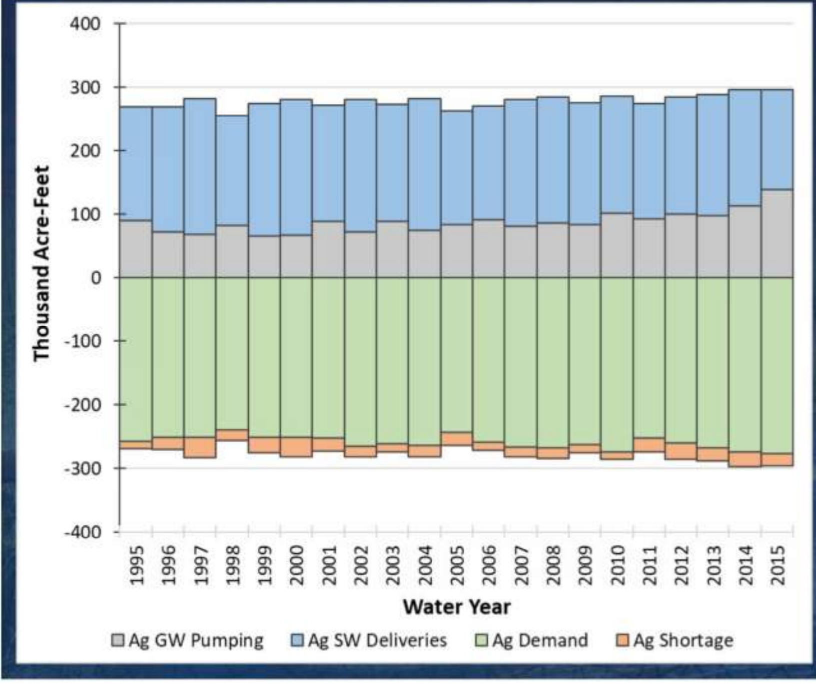


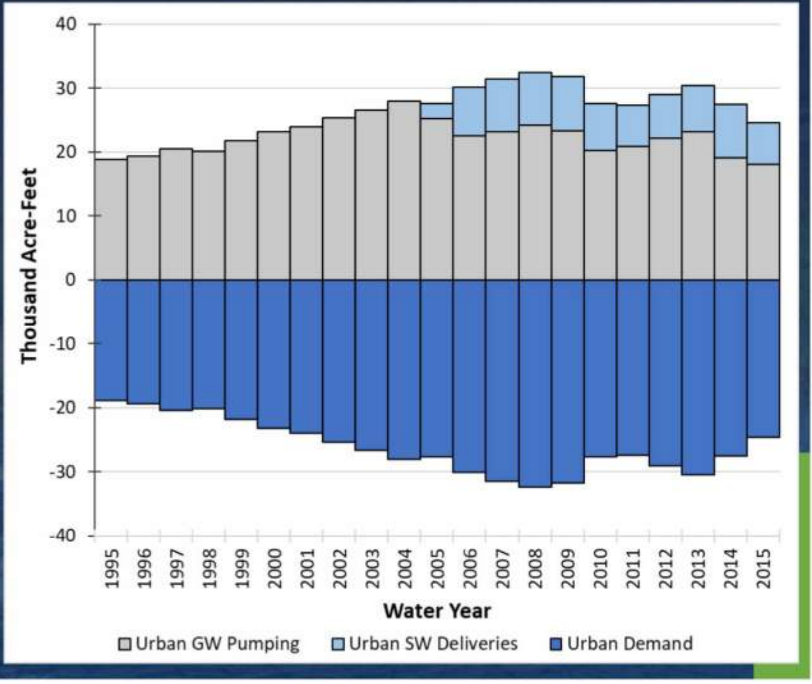
Central Subarea



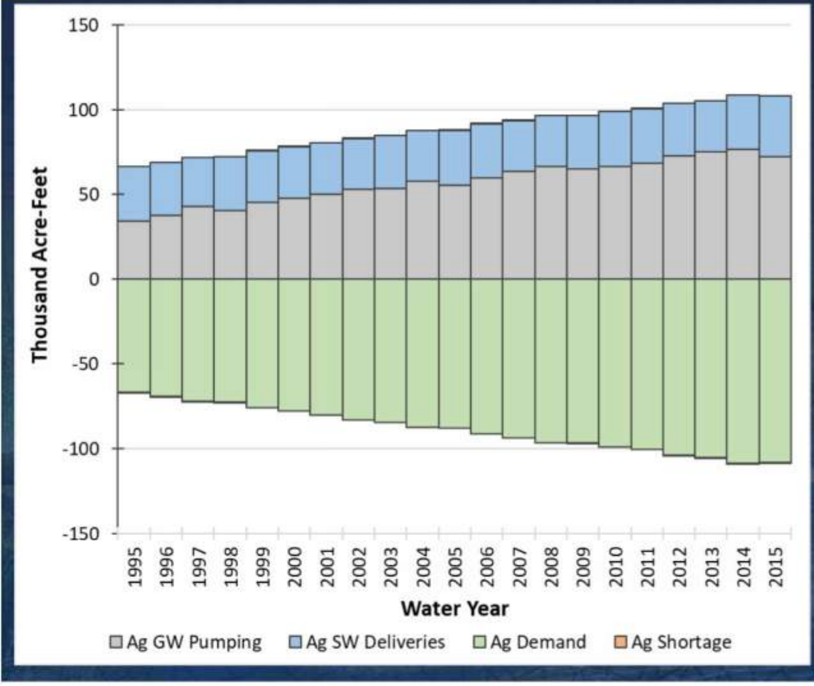


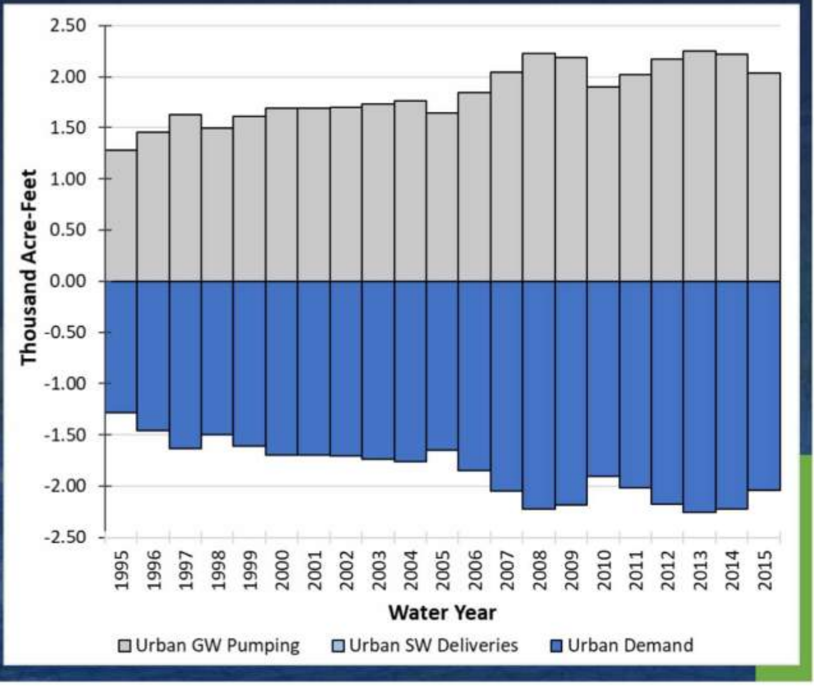
South Subarea





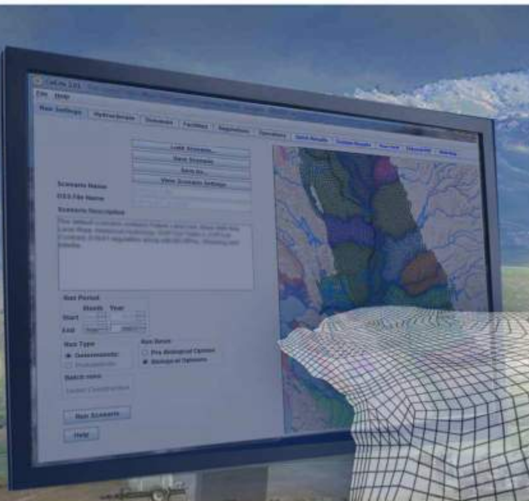
Stanislaus Subarea





Summary

- The **I**WFM **D**emand **C**alculator (IDC) simulates the agricultural and urban water demands in the ESJ model area
- The IDC input data and parameters, assumptions and results have been reviewed by the irrigation districts and agricultural community in the ESJ Subbasin
- The IDC data, assumptions and results have also been presented in a number of stakeholder workshops at the SJ County
- There is general consensus that the IDC reasonably simulates the agricultural and urban water use in the ESJ Subbasin
- The IDC will be incorporated in the ESJWRM to simulate the integrated SW/GW conditions in the ESJ Subbasin



Sustainable Groundwater Management Act Readiness Project

ESJ Water Resources Model (ESJWRM) Development Update- Calibration Workshop

RMC water and environment

WOODARD & CURRAN

National Experience. Local Focus.

SAN JOAQUIN COUNTY CALIFORNIA

April 25, 2018

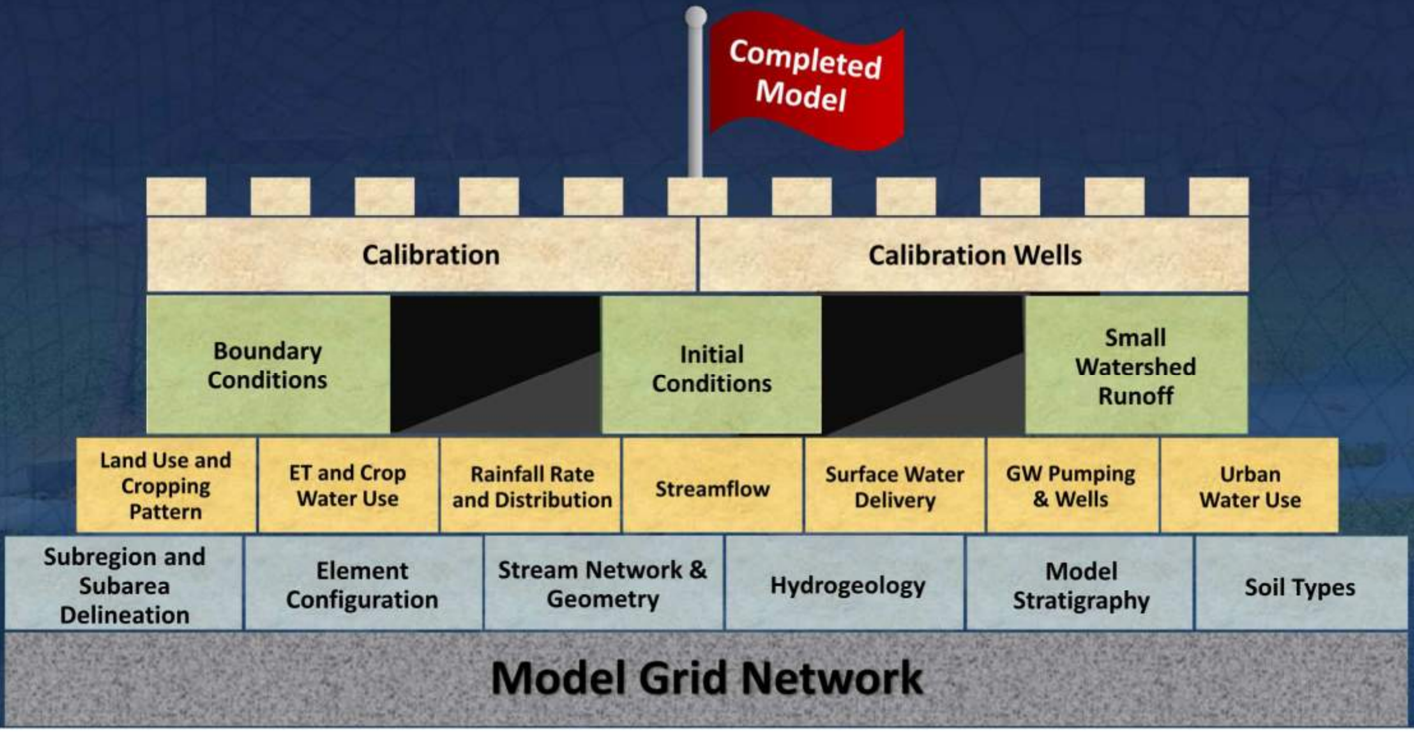
Agenda

1. Stakeholder Workshop for IDC
2. Model Calibration Workshop
3. Sustainability Indicator Questionnaire

Calibration Workshop Agenda

- Calibration Process
- GWL Calibration
  - Wells
  - Statistics
  - Hydrographs
  - Contours
- GW Budgets
- Streamflow Calibration
  - Stations
  - Hydrographs
- Next Steps

ESJWRM Construction


Completed Model

Calibration | Calibration Wells

Boundary Conditions | Initial Conditions | Small Watershed Runoff

Land Use and Cropping Pattern | ET and Crop Water Use | Rainfall Rate and Distribution | Streamflow | Surface Water Delivery | GW Pumping & Wells | Urban Water Use

Subregion and Subarea Delineation | Element Configuration | Stream Network & Geometry | Hydrogeology | Model Stratigraphy | Soil Types

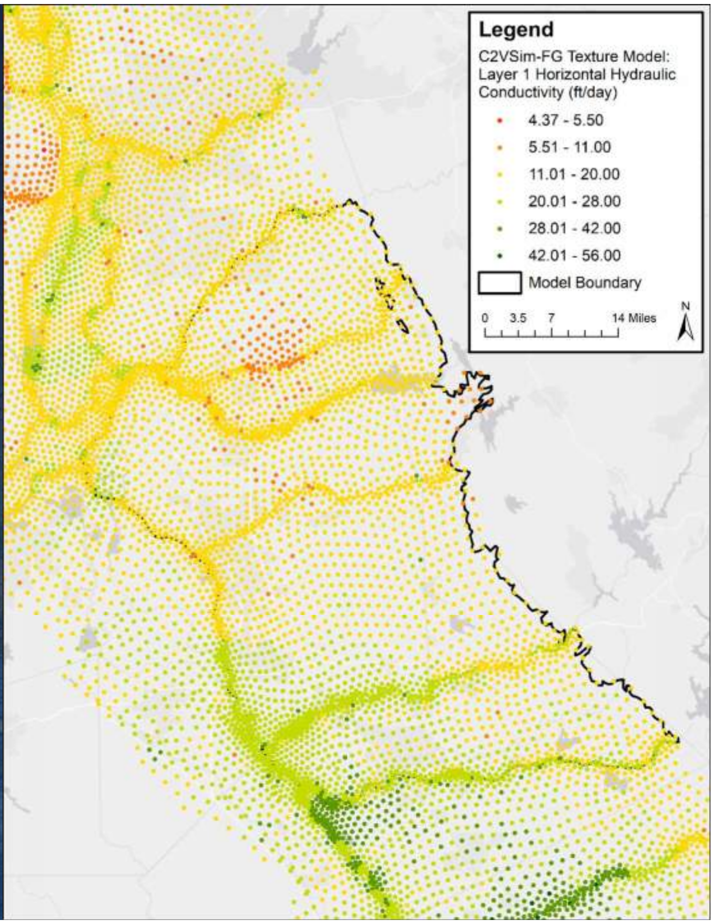
Model Grid Network

Calibration Process

- Identify:
  - Target calibration wells
  - Target streamflow gaging stations
- Review observed data and set calibration targets
- Calibrate model by adjusting model parameters to attain reasonable match between modeled and observed data for:
  - Water budgets for each component of the hydrologic cycle modeled
  - GW levels at select wells
  - Streamflows at select gaging stations
- Compare calibration performance with calibration targets
- Conduct additional refinements as necessary

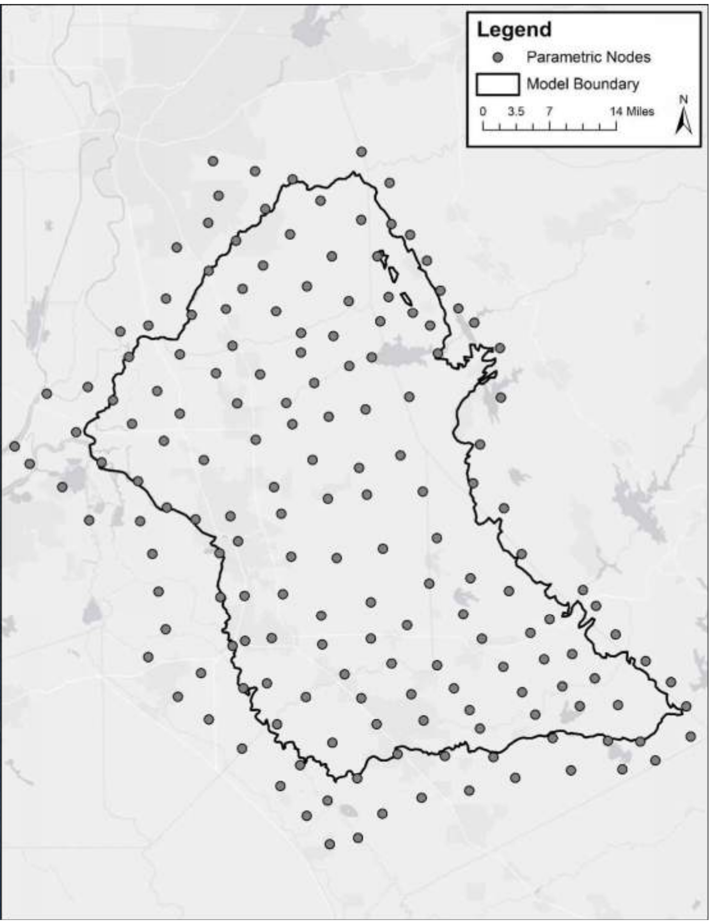
Calibration Process

- Assign initial aquifer parameters using texture model
- Aquifer parameters include:
  - Horizontal hydraulic conductivity
  - Vertical hydraulic conductivity (both aquifer and aquitard)
  - Specific storage
  - Specific yield



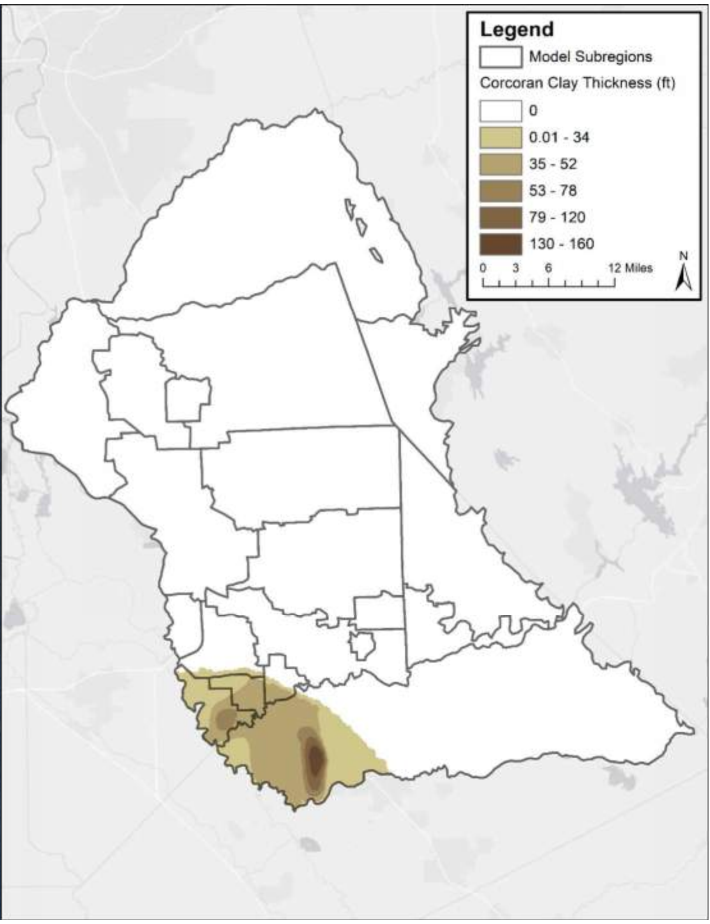
Calibration Process

- Aquifer parameters assigned for each of the four model stratigraphic layers by parametric node
- Texture-based parameters are mapped to the ESJWRM Parametric nodes, which are the C2VSim-CG groundwater nodes in the ESJWRM area (171 C2VSim-CG nodes)



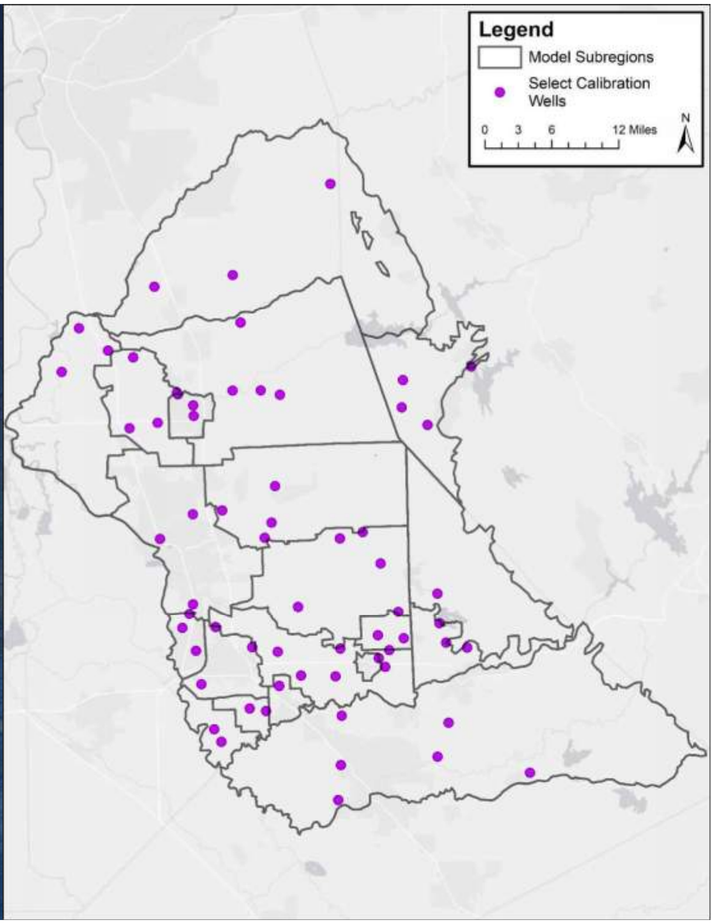
Calibration Process

- Determined model sensitivity to editing parameters:
  - Horizontal hydraulic conductivity
    - Affects spatial movement of groundwater within model area
  - Vertical hydraulic conductivity (both aquifer and aquitard)
    - Aquitard only for area with Corcoran Clay
    - Aquifer affects interaction between layers
  - Specific storage
    - Affects confined aquifer (Layers 2, 3, and 4)
  - Specific yield
    - Affects unconfined aquifer (Layer 1)

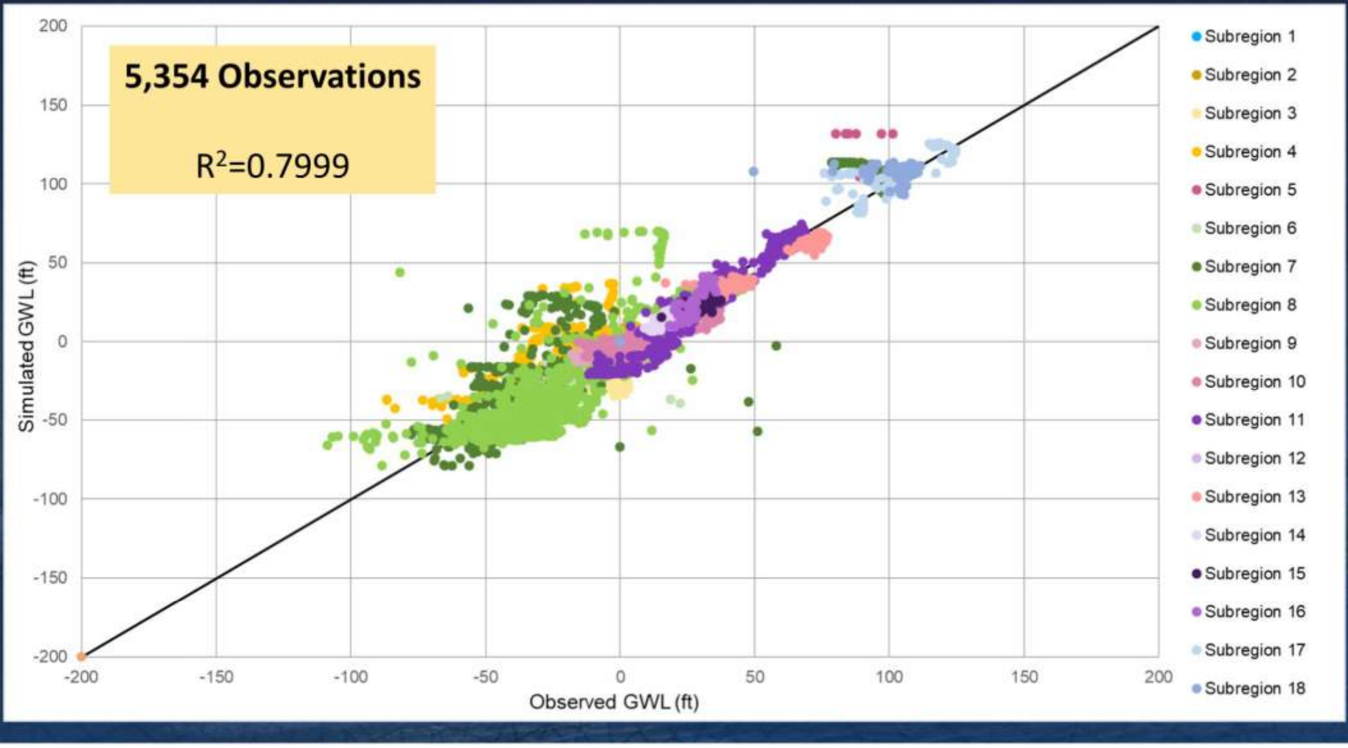


GWL Calibration Wells

- 160 model calibration wells selected to represent spatial and temporal variability across model time period
- As many as 63 model calibration wells selected to represent calibration and GWL trends across the model area

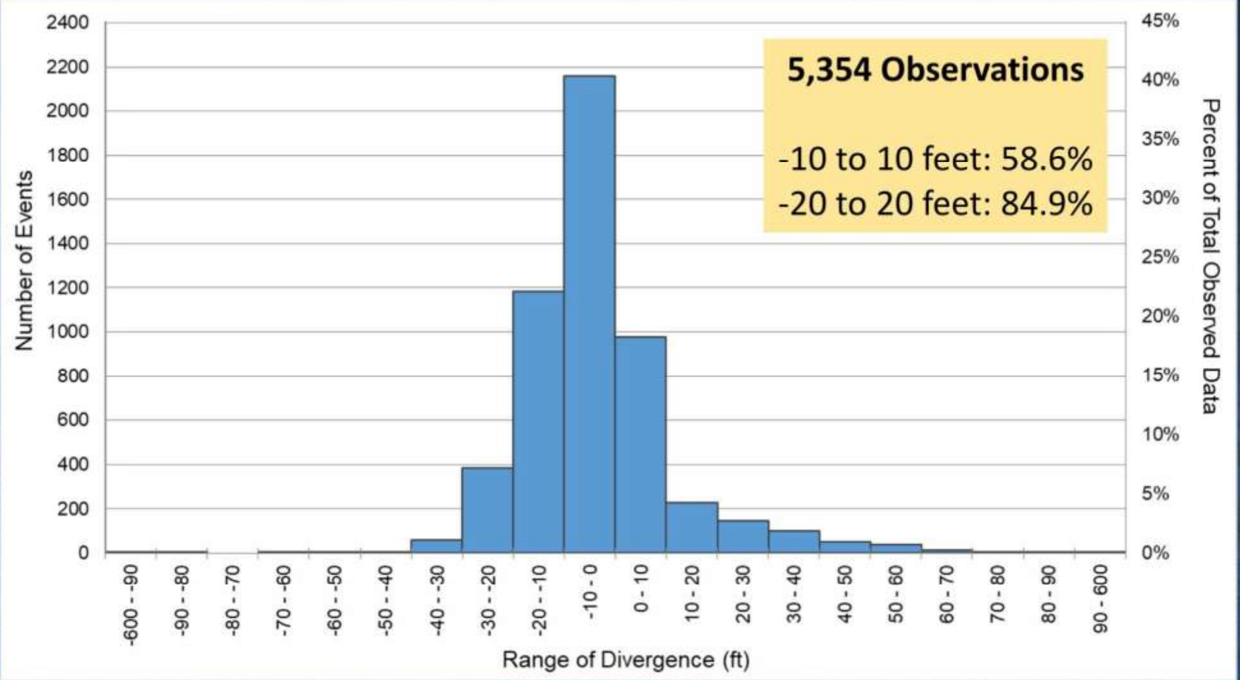


GWL Calibration Statistics


5,354 Observations

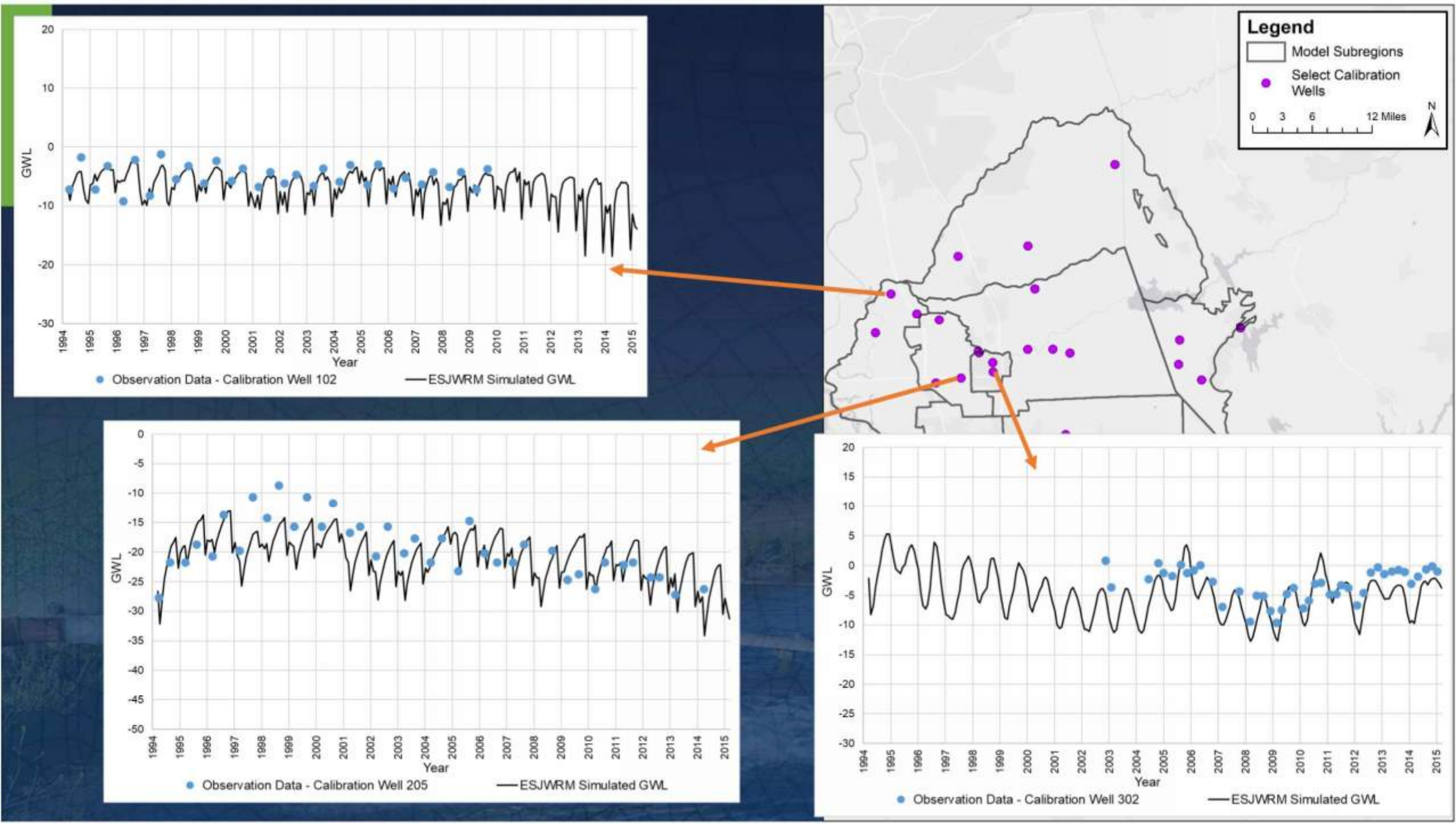
R^2=0.7999

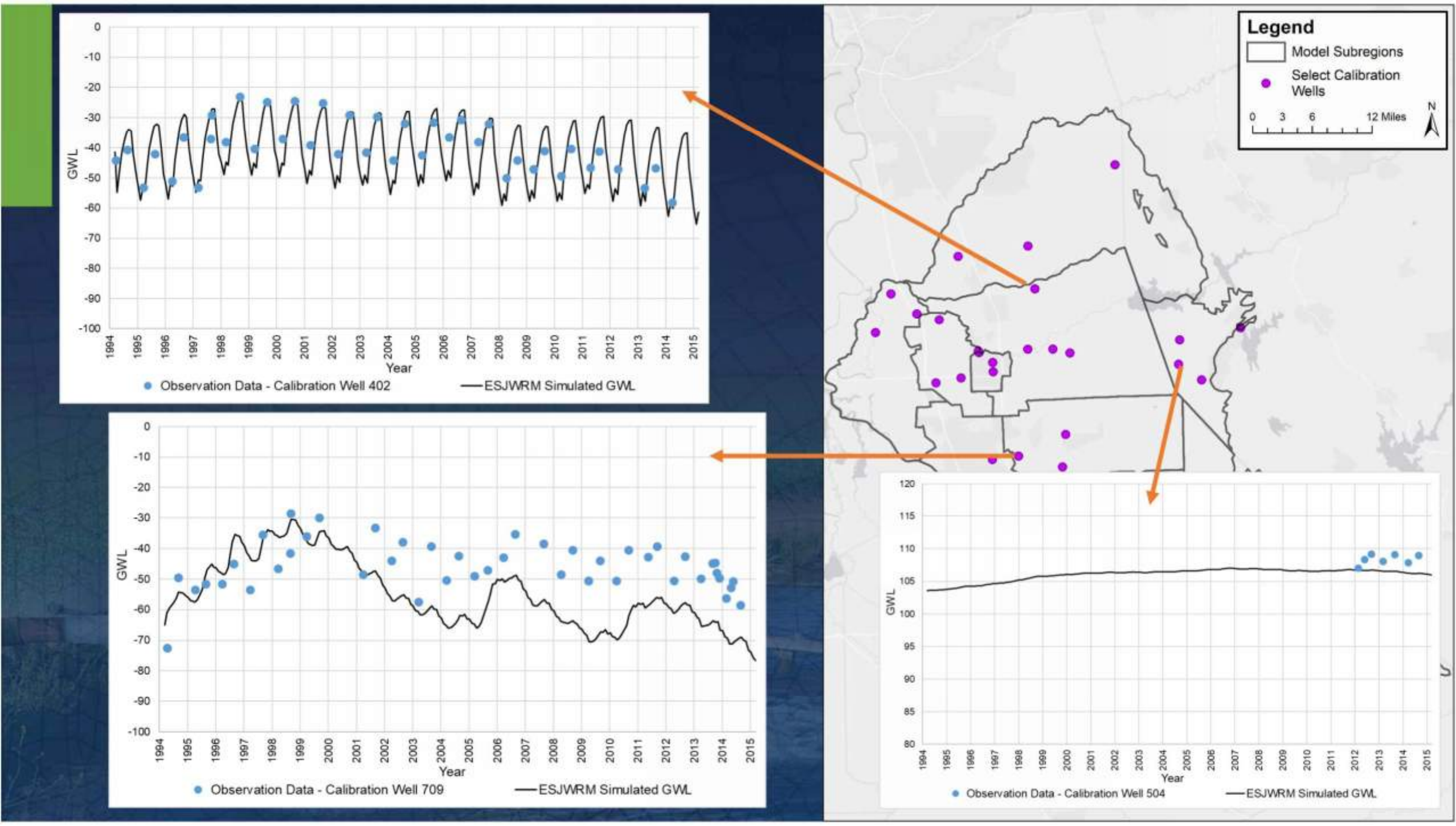
GWL Calibration Statistics

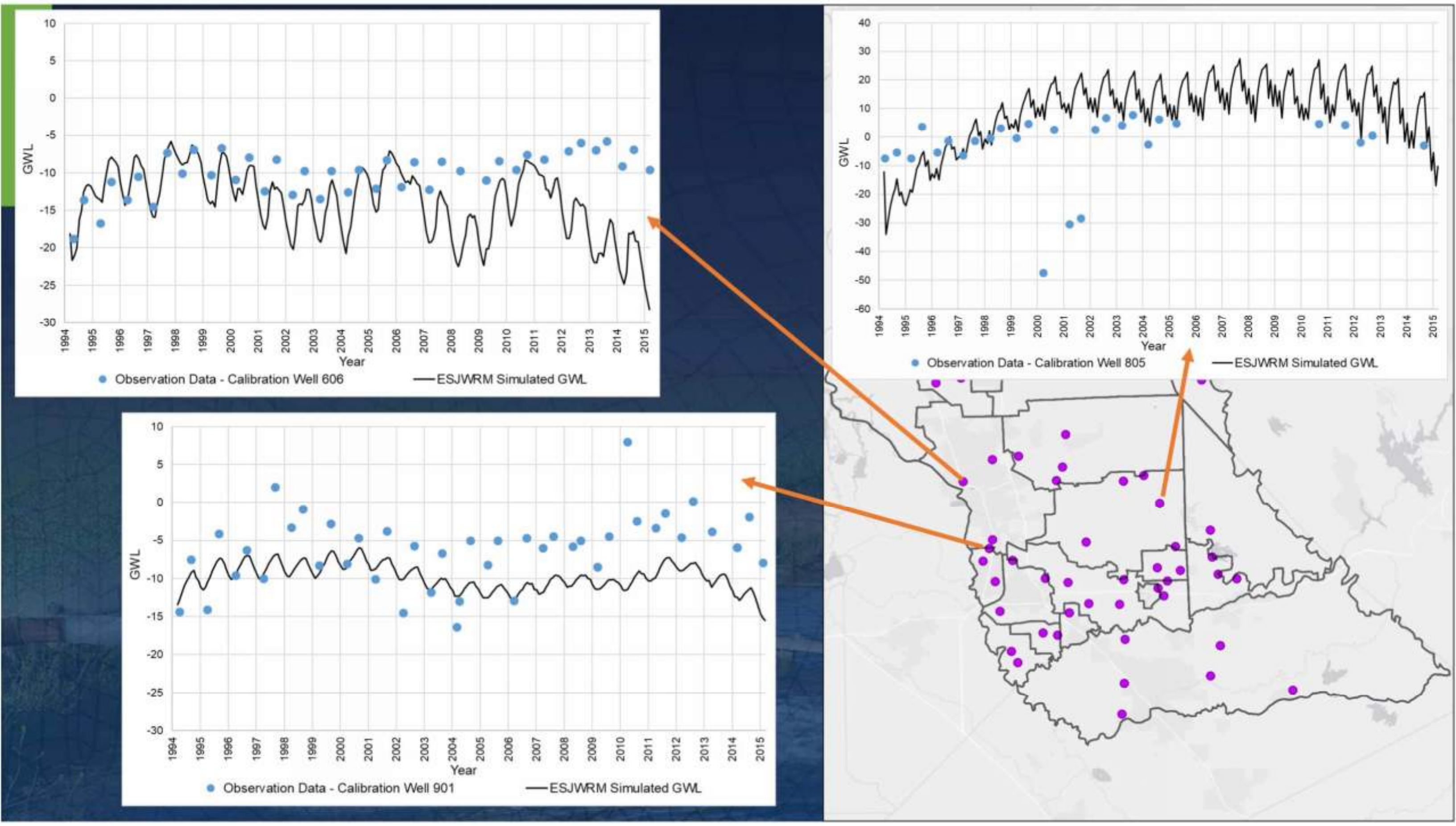


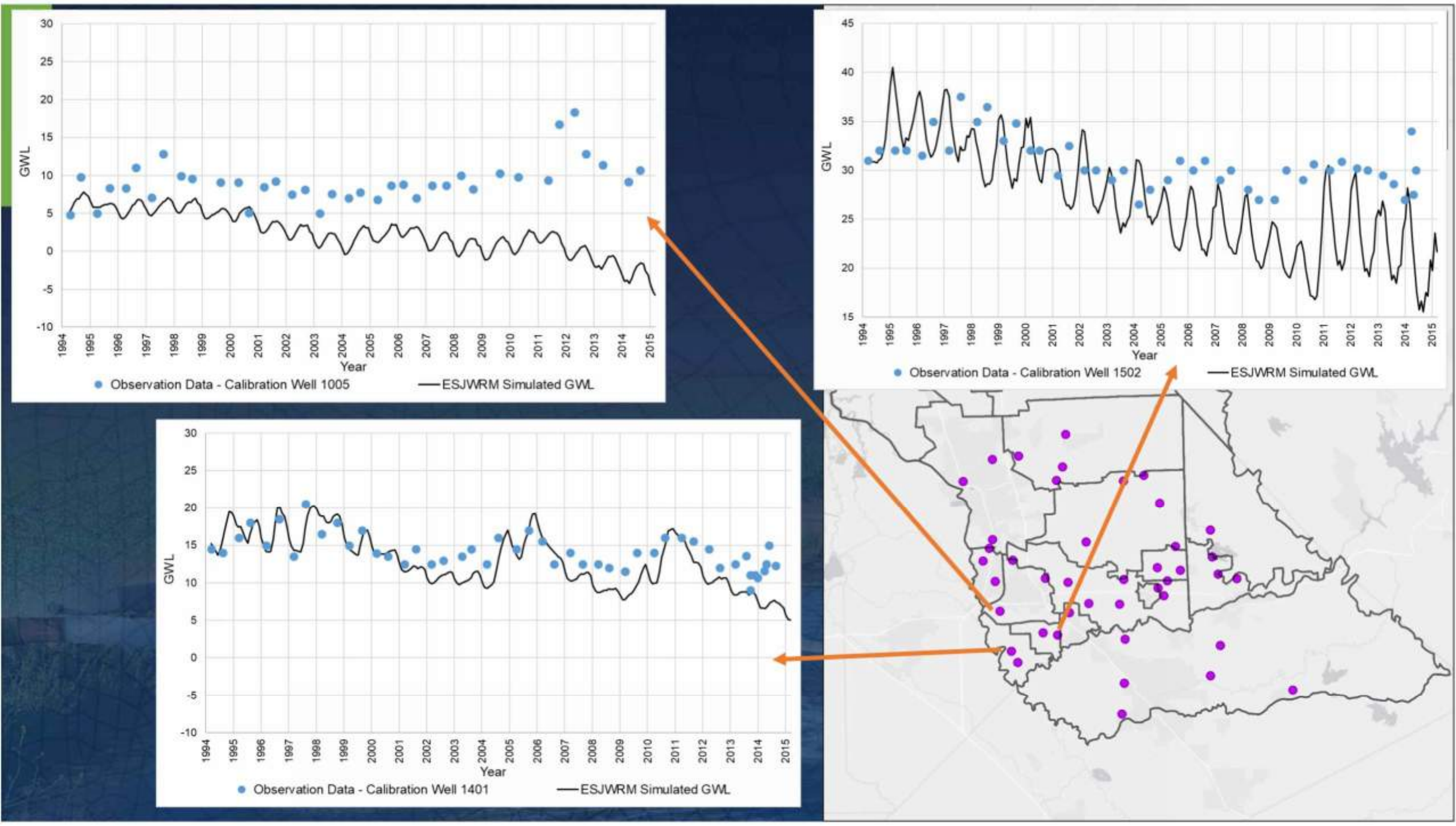
5,354 Observations

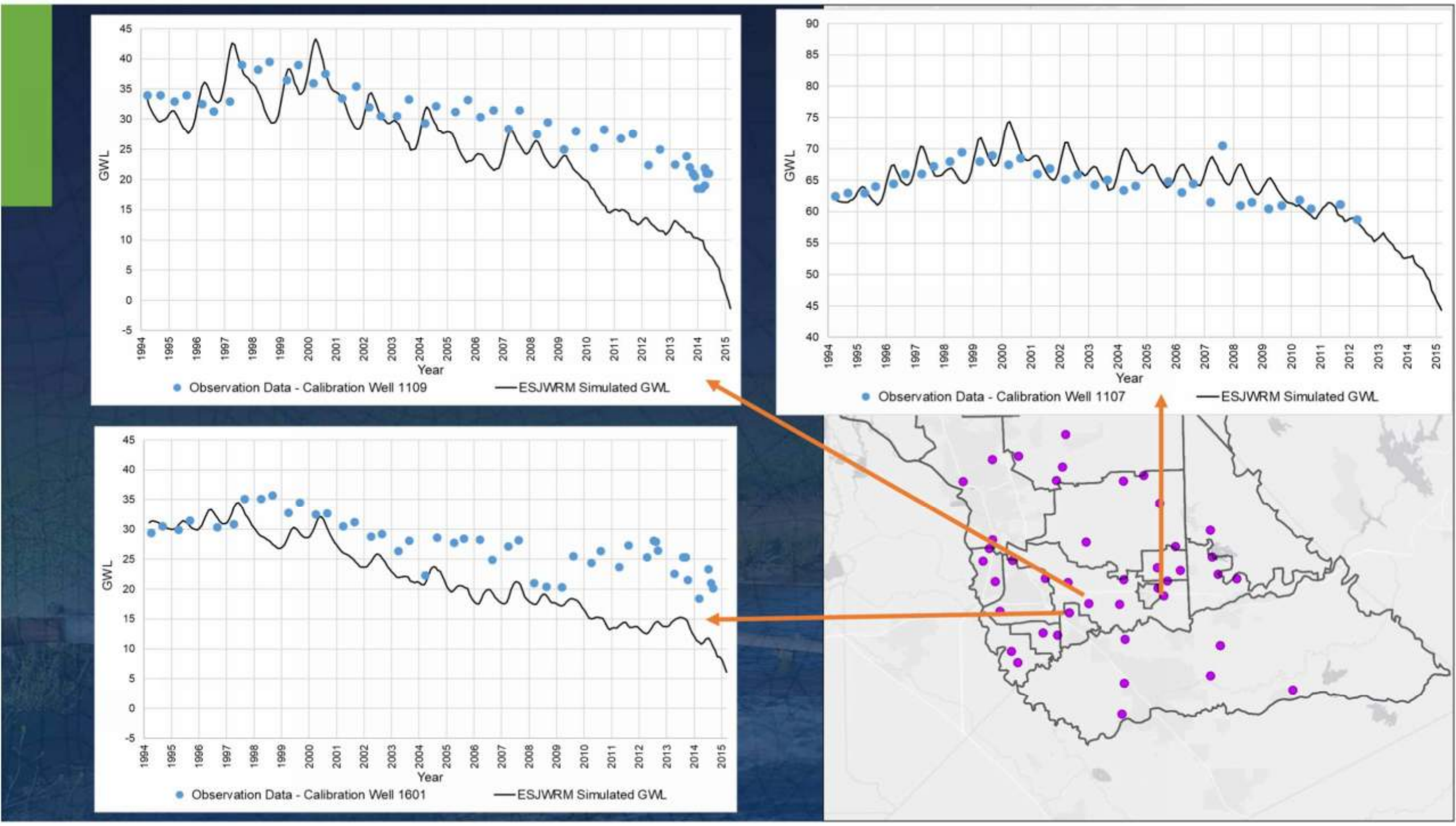
-10 to 10 feet: 58.6%
-20 to 20 feet: 84.9%

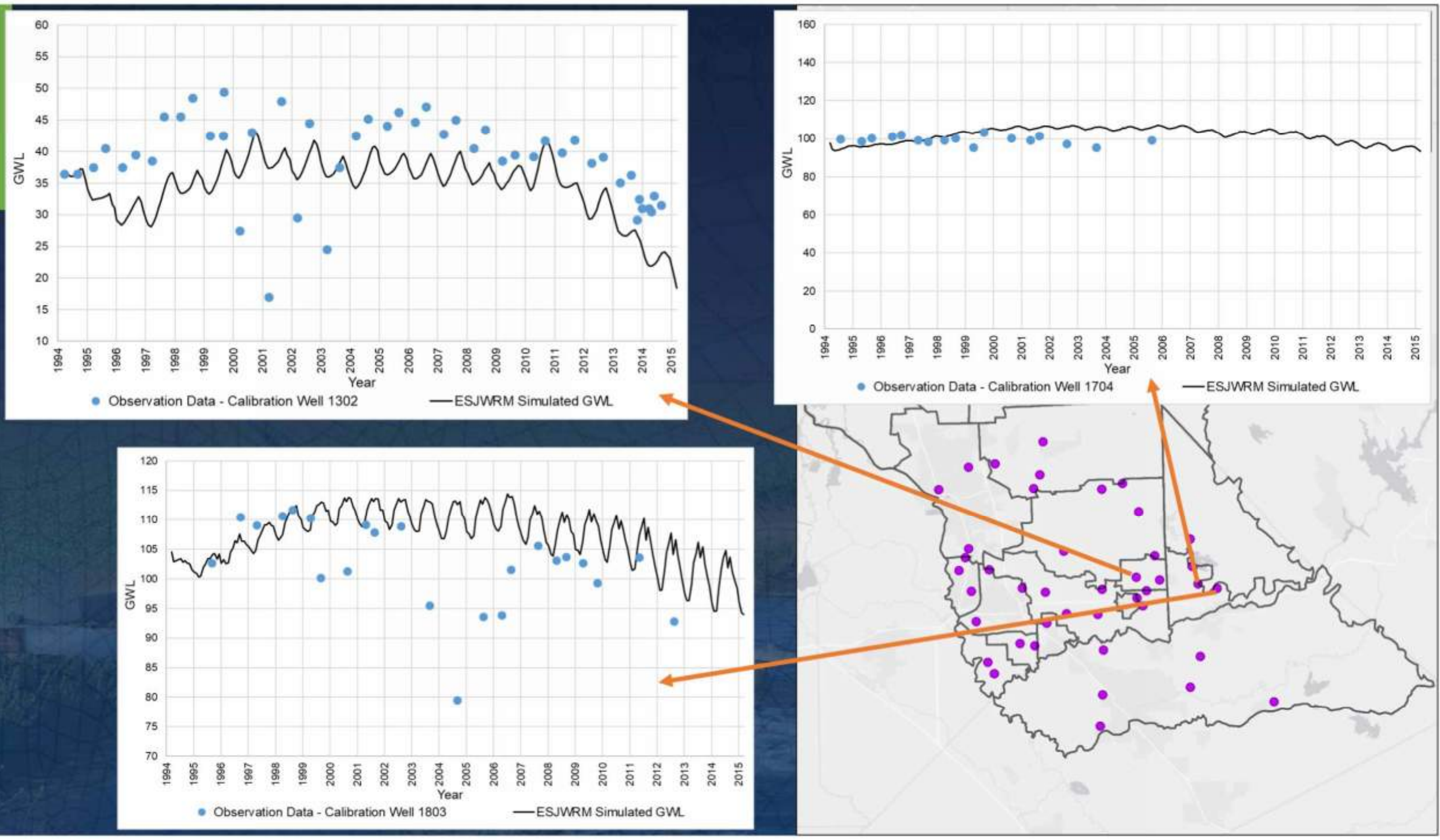



Legend
Model Subregions
Select Calibration Wells
0 3 6 12 Miles
N
GWL
Year
Observation Data - Calibration Well 402
ESJWRM Simulated GWL
Observation Data - Calibration Well 709
ESJWRM Simulated GWL
Observation Data - Calibration Well 504
ESJWRM Simulated GWL

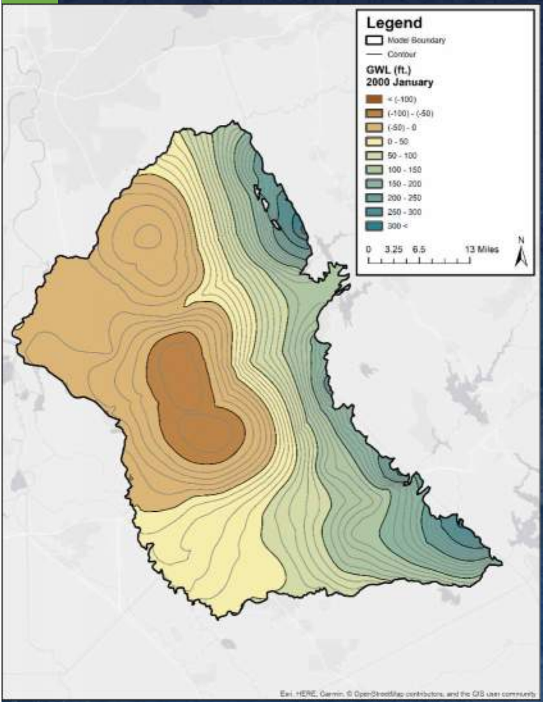

GWL
Year
Observation Data - Calibration Well 606
ESJWRM Simulated GWL
Observation Data - Calibration Well 805
ESJWRM Simulated GWL
Observation Data - Calibration Well 901
ESJWRM Simulated GWL


GWL
Year
Observation Data - Calibration Well 1005
ESJWRM Simulated GWL
Observation Data - Calibration Well 1502
ESJWRM Simulated GWL
Observation Data - Calibration Well 1401
ESJWRM Simulated GWL
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015

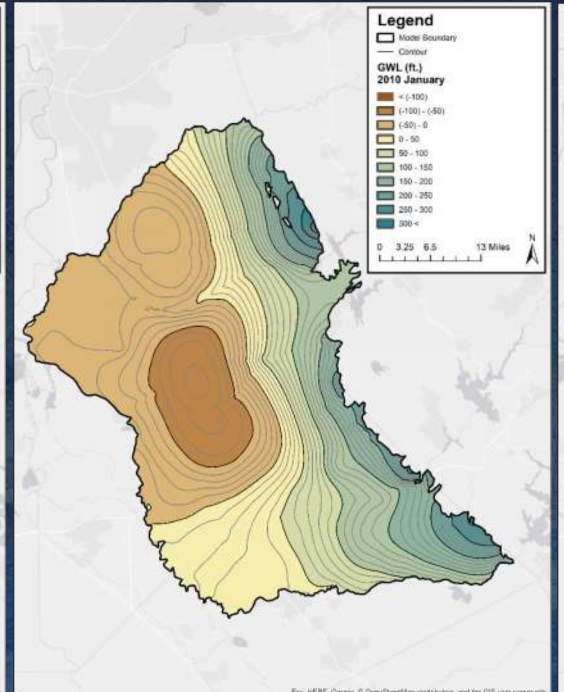

GWL
Year
Observation Data - Calibration Well 1109
ESJWRM Simulated GWL
Observation Data - Calibration Well 1107
ESJWRM Simulated GWL
Observation Data - Calibration Well 1601
ESJWRM Simulated GWL
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015



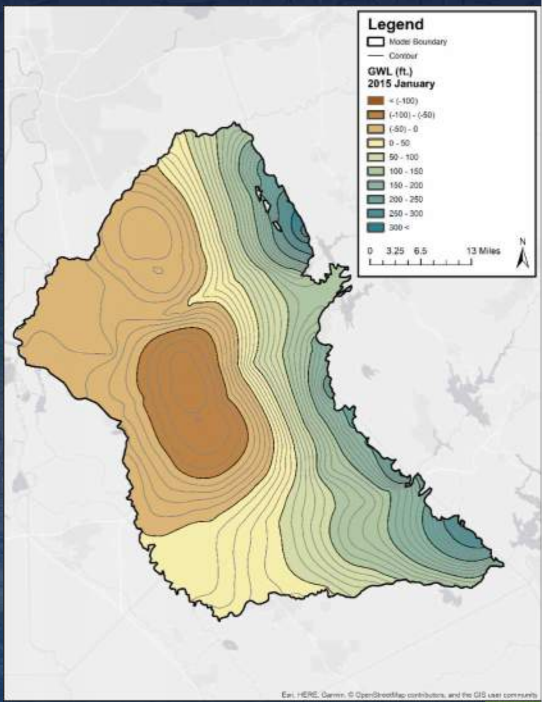
GWL Contours



January 2000



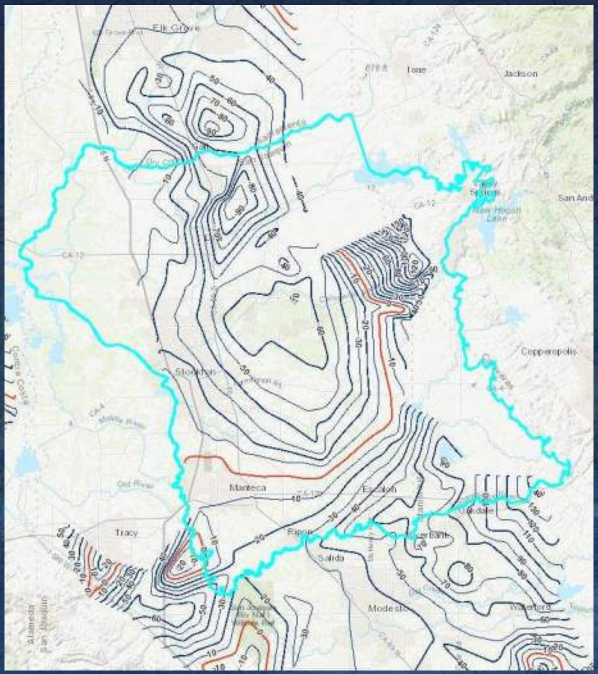
January 2010

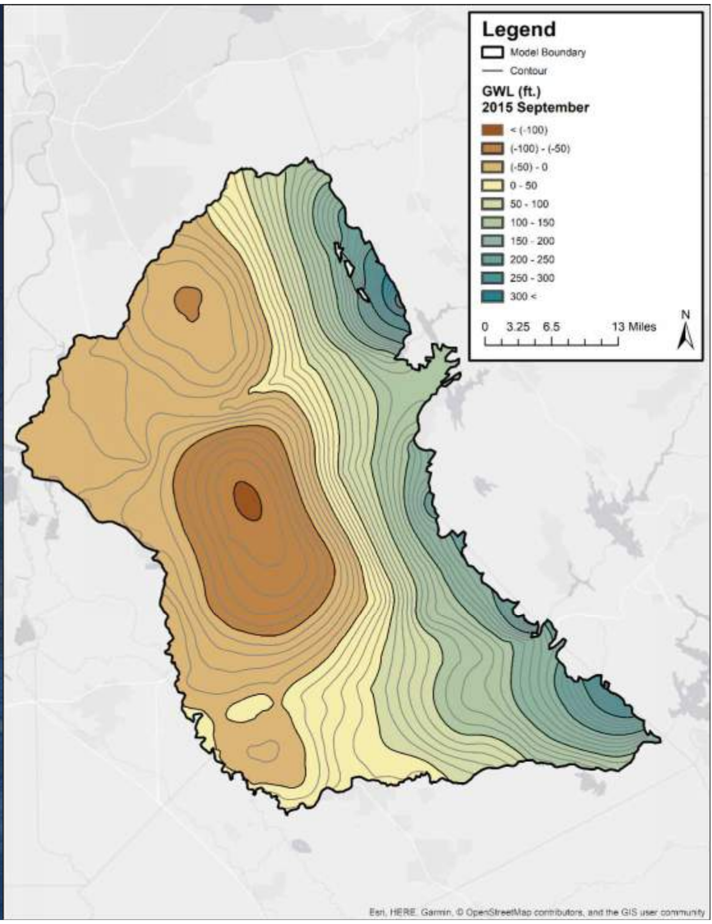


January 2015

GW Level Animation

Fall 2015

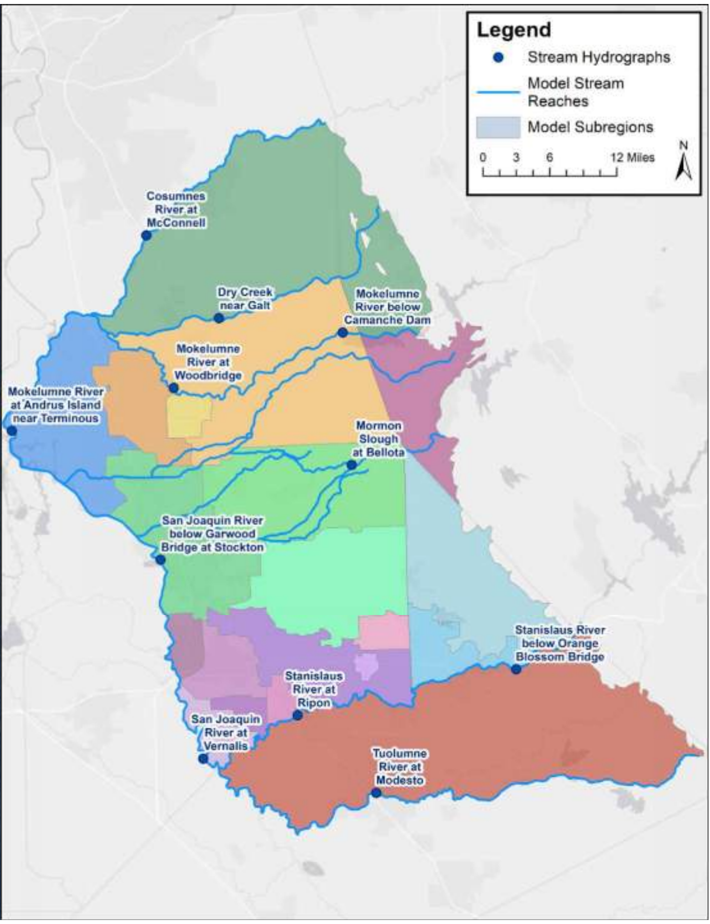


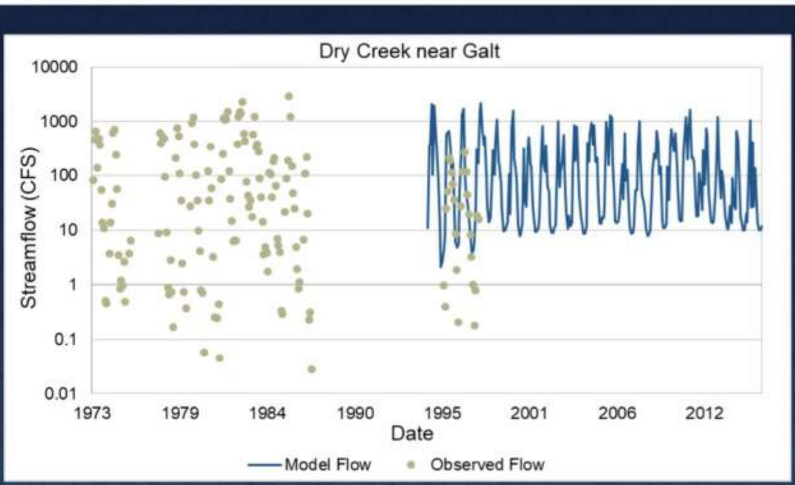


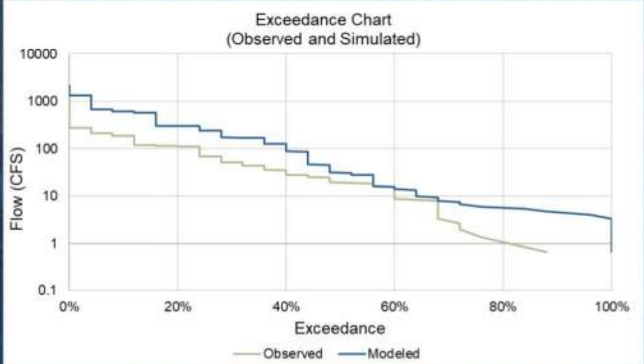
Esri, HERE, Garmin, © OpenStreetMap contributors, and the GIS user community

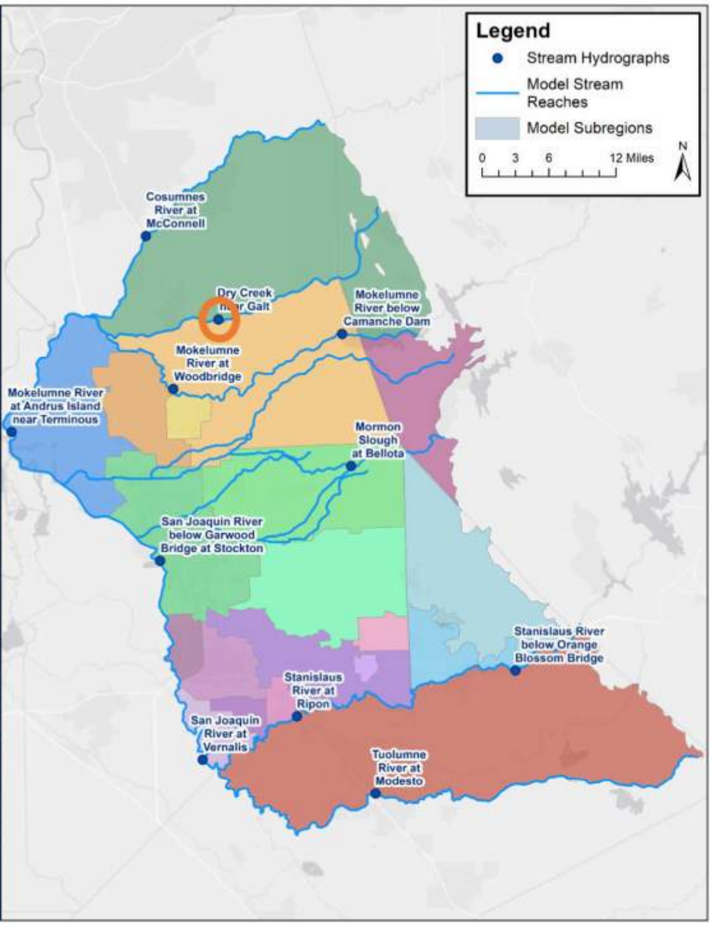
Streamflow Calibration Stations

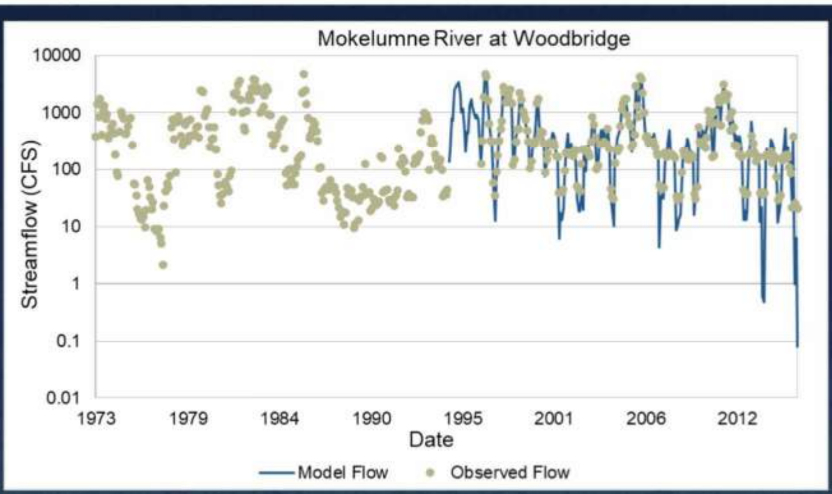
- 11 streamflow calibration stations
  - USGS, USACE, or DWR CDEC
- Since boundary of model is largely controlled by boundary conditions, important stations are those interior in the model

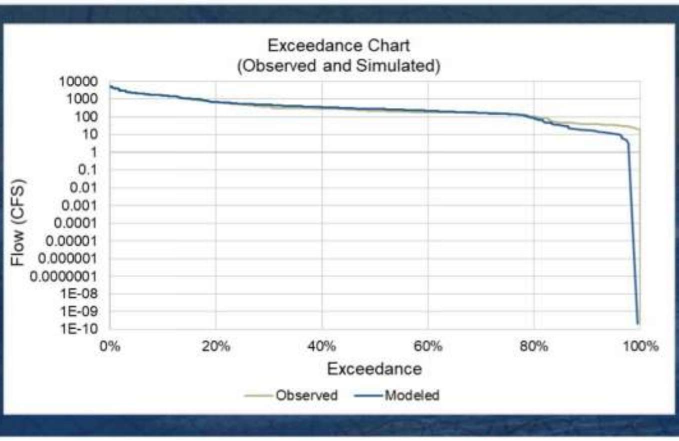


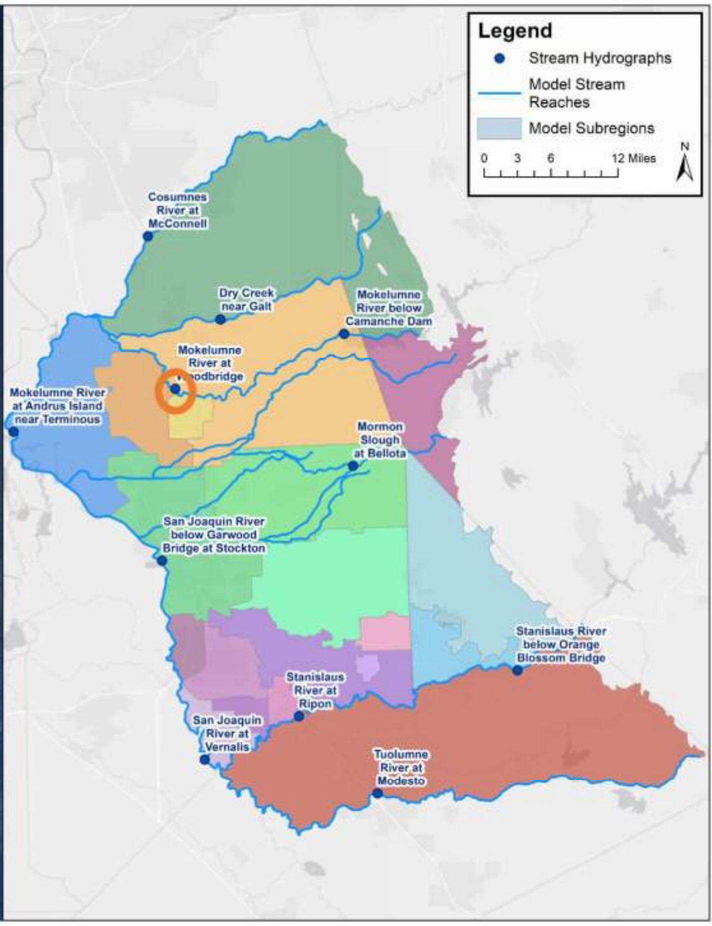


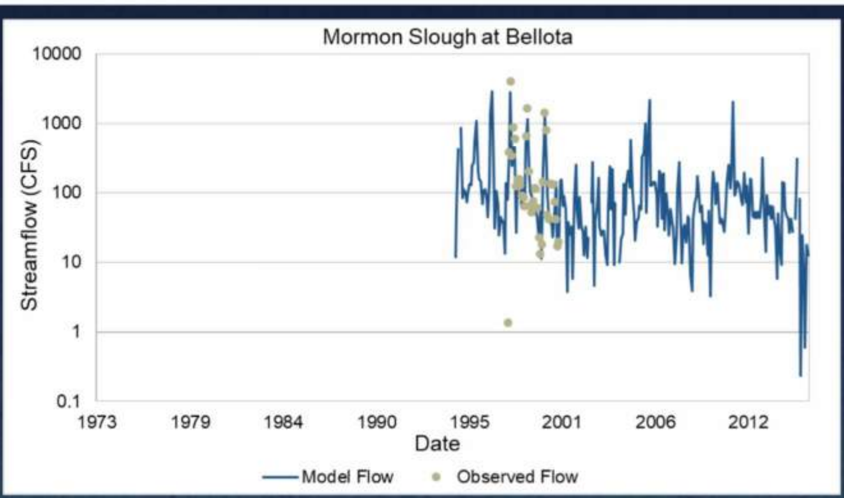


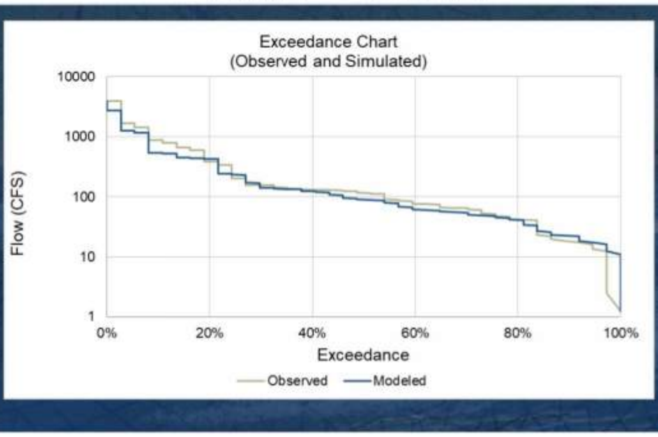


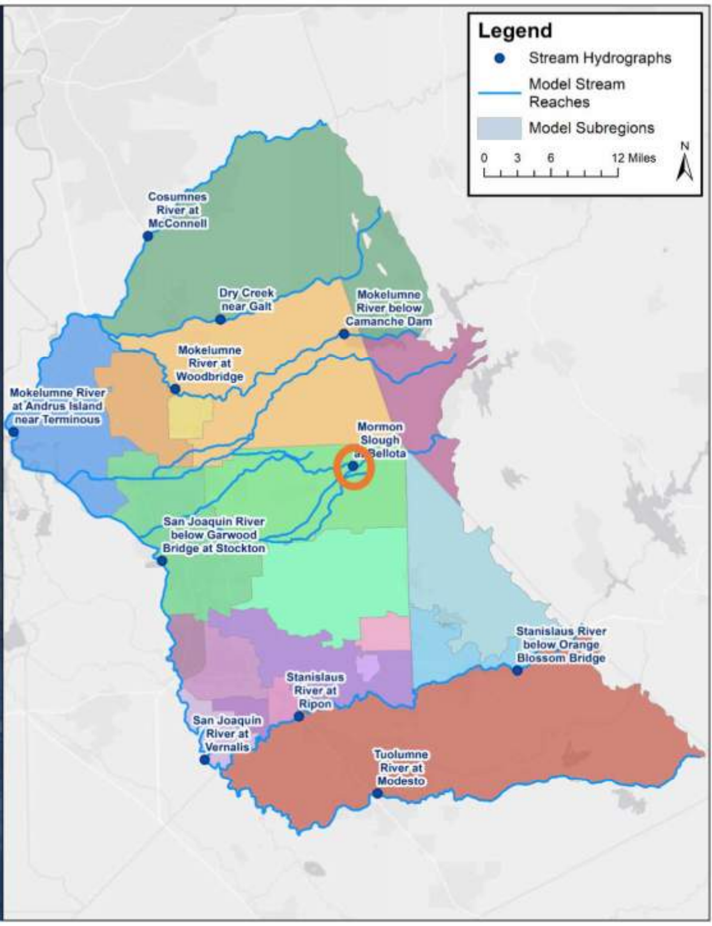

Mokelumne River at Woodbridge
Streamflow (CFS)
10000
1000
100
10
1
0.1
0.01
1973
1979
1984
1990
1995
2001
2006
2012
Date
Model Flow
Observed Flow

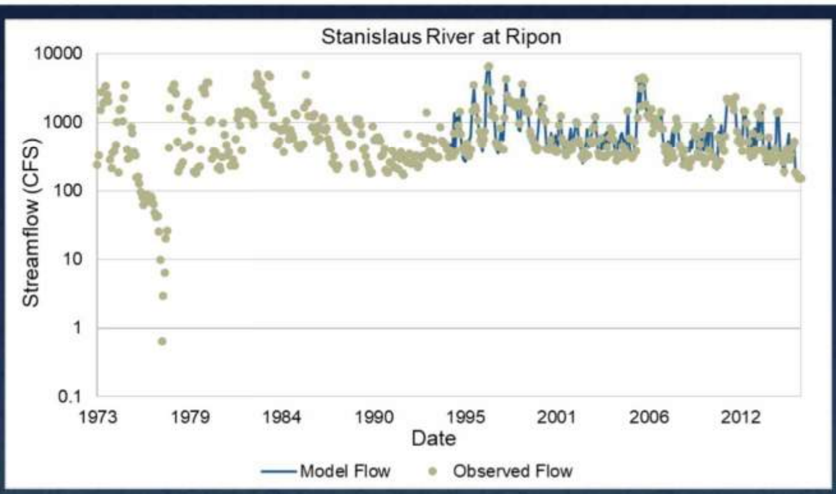

Exceedance Chart
(Observed and Simulated)
Flow (CFS)
10000
1000
100
10
1
0.1
0.01
0.001
0.0001
0.00001
0.000001
0.0000001
1E-08
1E-09
1E-10
0%
20%
40%
60%
80%
100%
Exceedance
Observed
Modeled

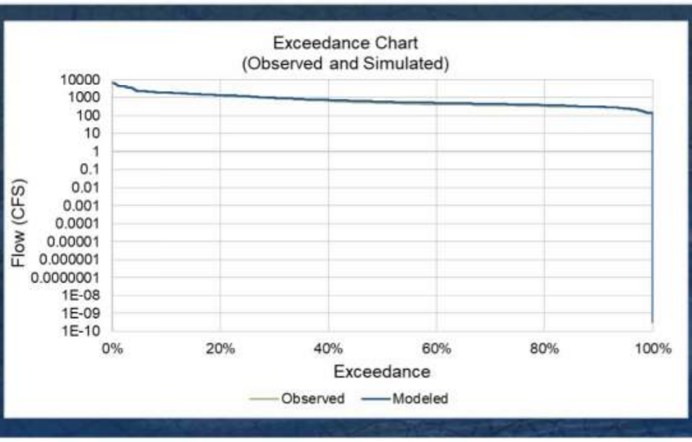

Legend
Stream Hydrographs
Model Stream Reaches
Model Subregions
0 3 6 12 Miles
N
Cosumnes River at McConnell
Dry Creek near Galt
Mokelumne River below Camanche Dam
Mokelumne River at Woodbridge
Mokelumne River at Andrus Island near Terminous
Mormon Slough at Bellota
San Joaquin River below Garwood Bridge at Stockton
Stanislaus River below Orange Blossom Bridge
Stanislaus River at Ripon
San Joaquin River at Vernalis
Tuolumne River at Modesto

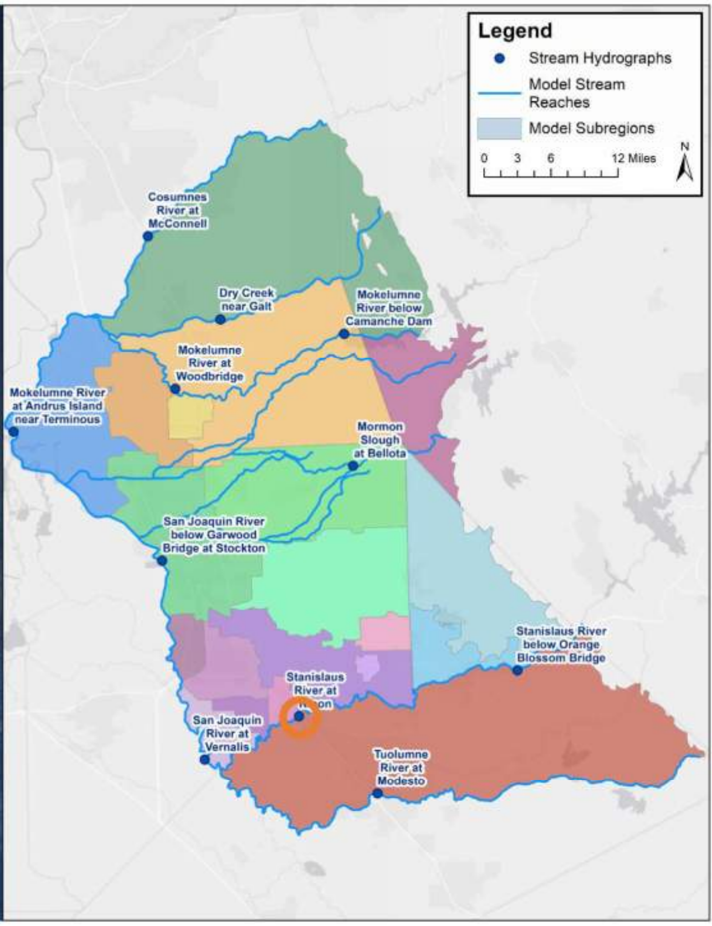

Mormon Slough at Bellota
Streamflow (CFS)
10000
1000
100
10
1
0.1
1973
1979
1984
1990
1995
2001
2006
2012
Date
Model Flow
Observed Flow


Exceedance Chart
(Observed and Simulated)
Flow (CFS)
10000
1000
100
10
1
0%
20%
40%
60%
80%
100%
Exceedance
Observed
Modeled

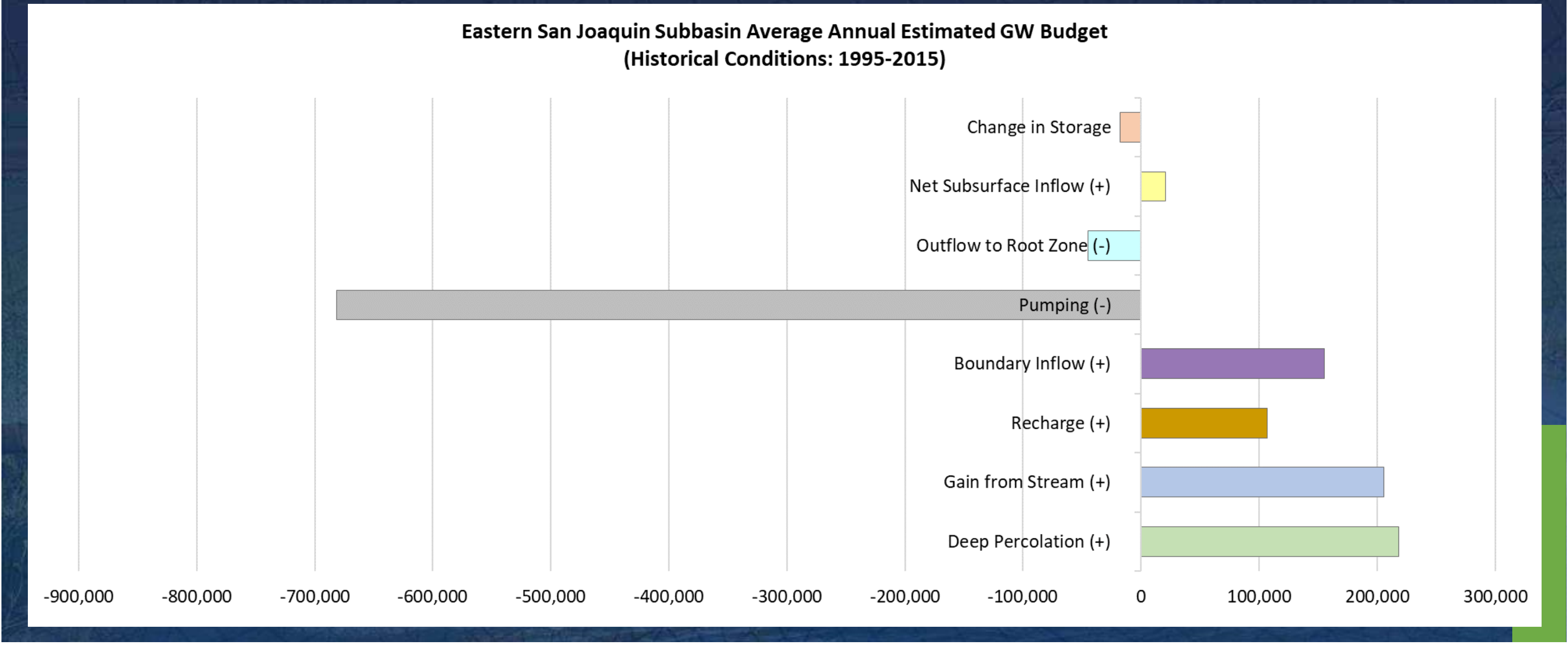

Legend
Stream Hydrographs
Model Stream Reaches
Model Subregions
0 3 6 12 Miles
N
Cosumnes River at McConnell
Dry Creek near Galt
Mokelumne River below Camanche Dam
Mokelumne River at Woodbridge
Mokelumne River at Andrus Island near Terminous
Mormon Slough at Bellota
San Joaquin River below Garwood Bridge at Stockton
Stanislaus River below Orange Blossom Bridge
Stanislaus River at Ripon
San Joaquin River at Vernalis
Tuolumne River at Modesto



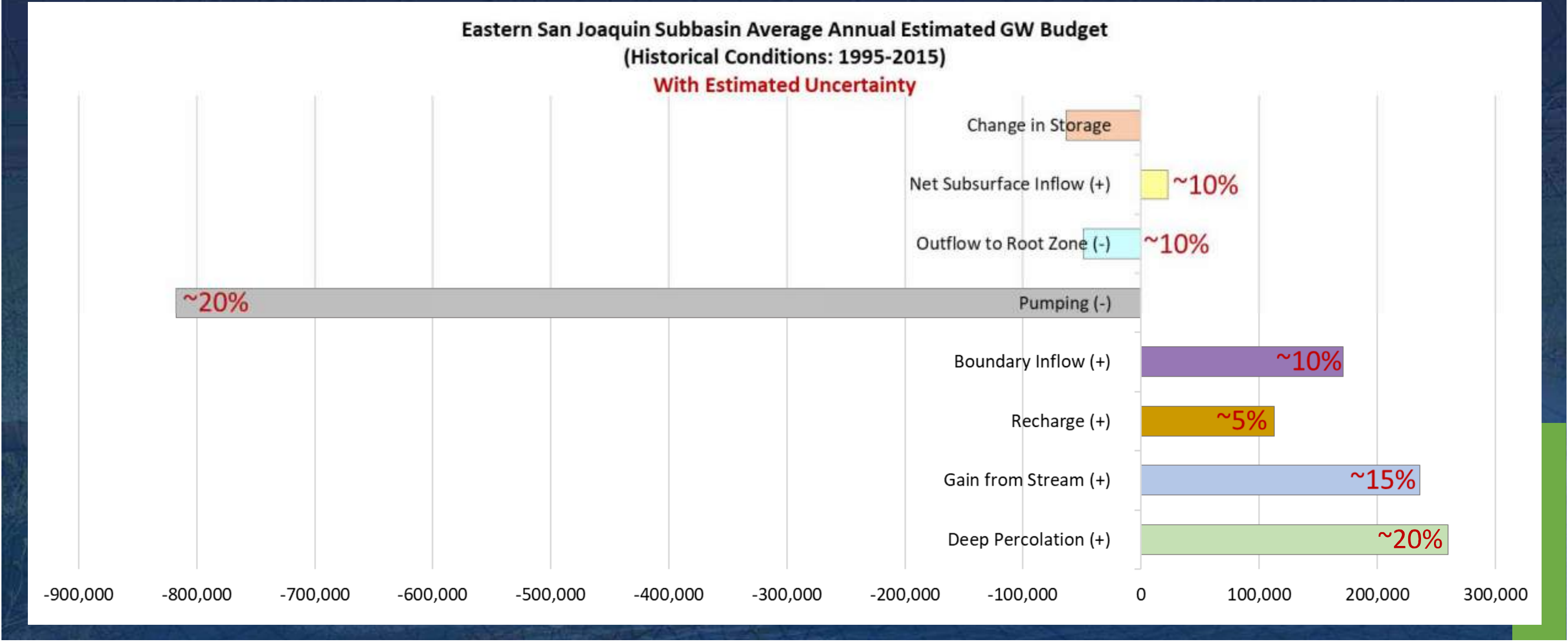




ESJ Subbasin Estimated Average Annual GW Budget Historical Conditions

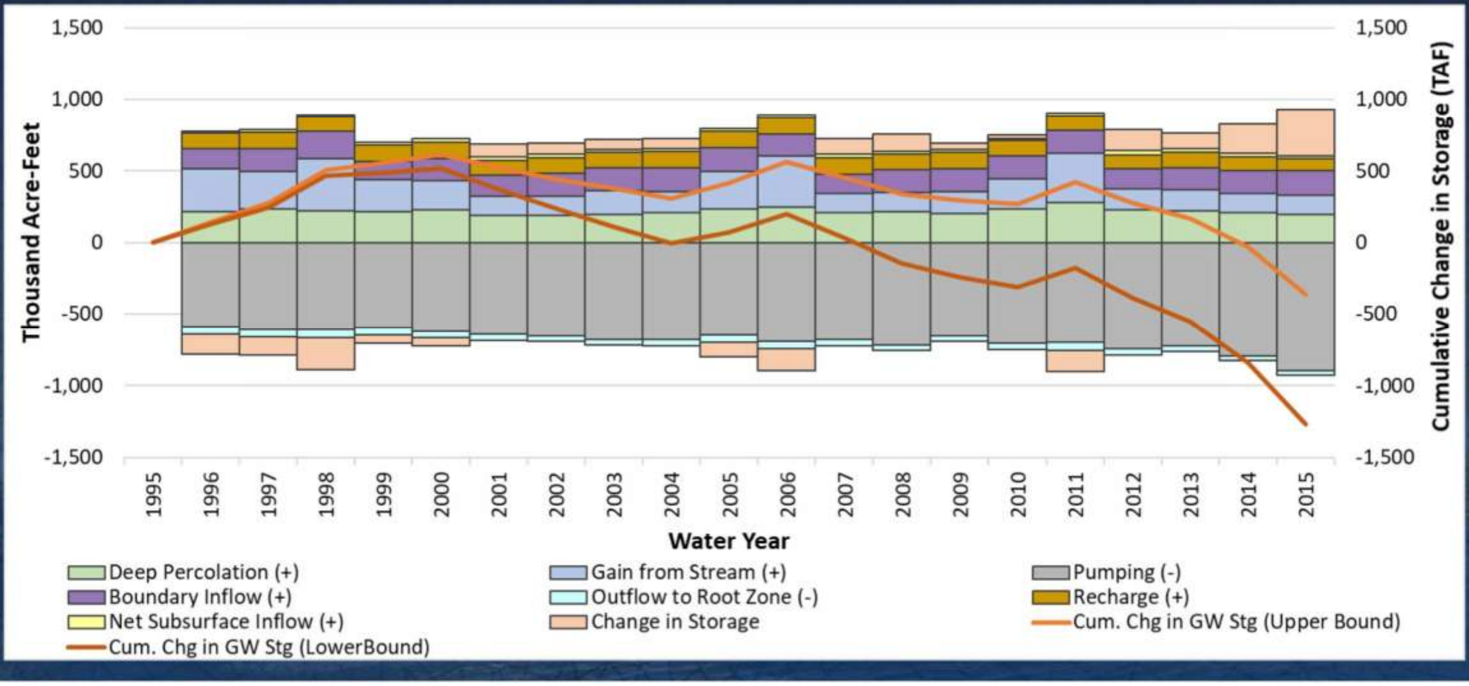

Eastern San Joaquin Subbasin Average Annual Estimated GW Budget
(Historical Conditions: 1995-2015)

ESJ Subbasin Estimated Average Annual GW Budget Historical Conditions



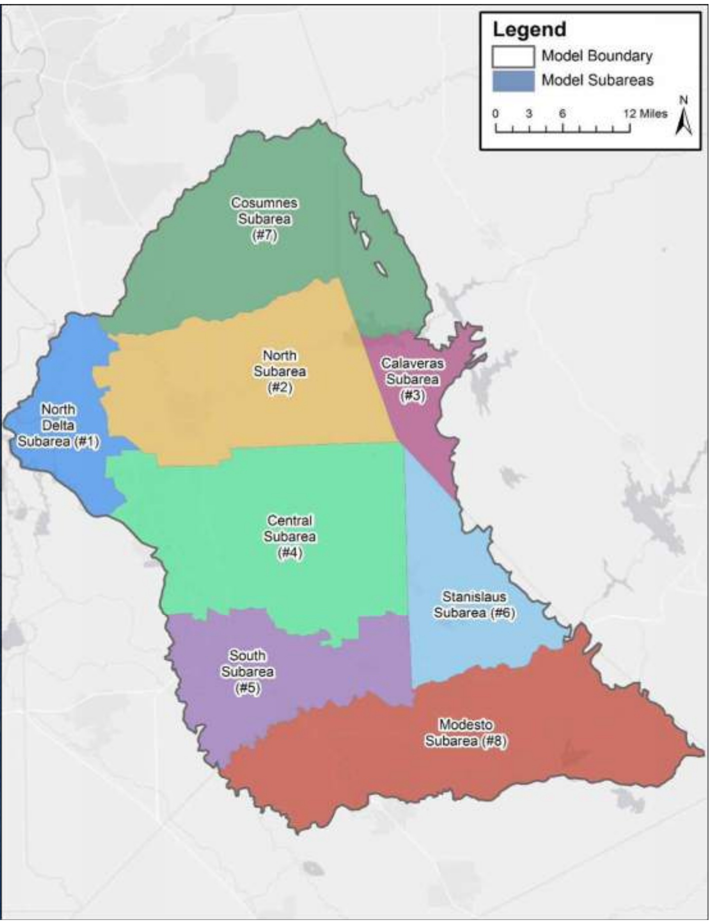
Eastern San Joaquin Subbasin Average Annual Estimated GW Budget
(Historical Conditions: 1995-2015)
With Estimated Uncertainty

ESJ Subbasin Estimated Average Annual GW Budget Historical Conditions

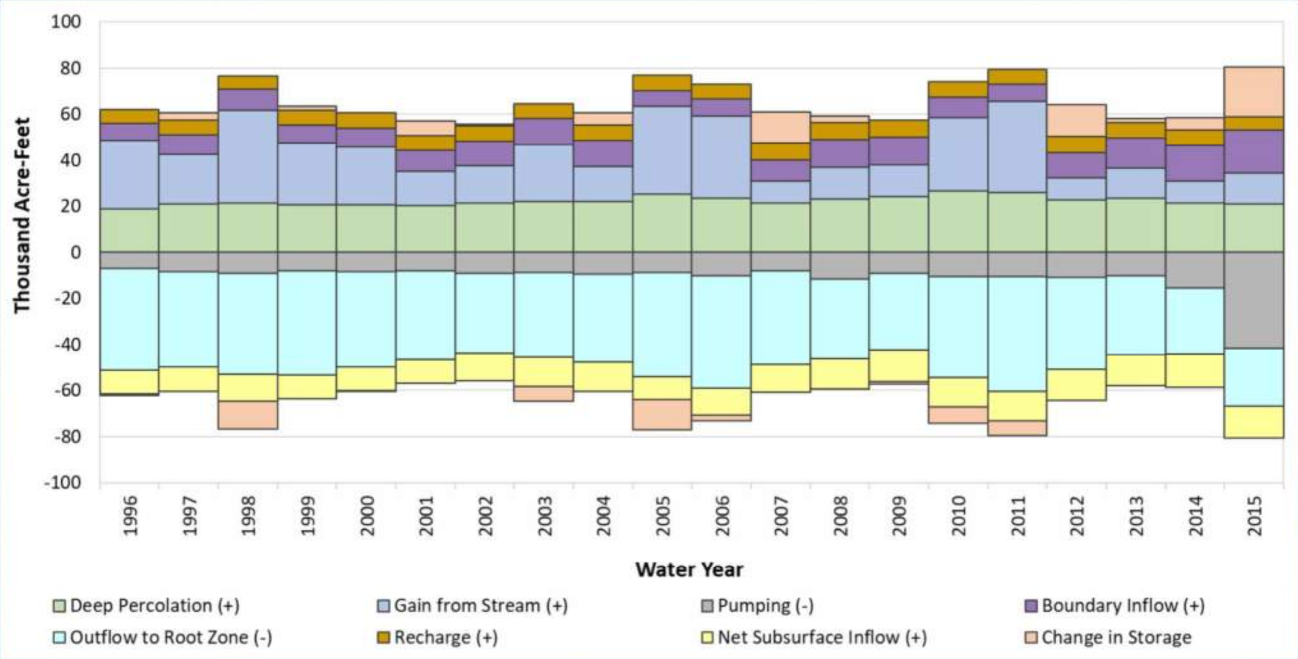


Budgets by Subarea

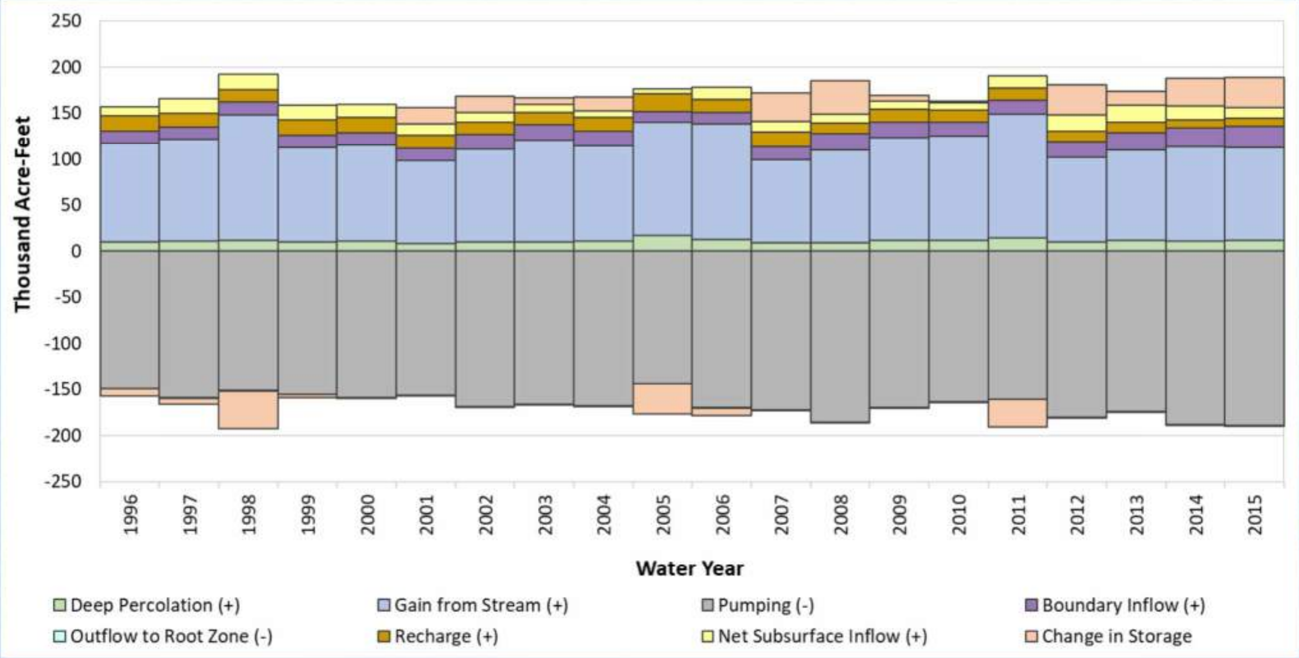
- Data input subregions versus model output subareas
  - For data verification and QA/QC, focus has been on data input subregions
  - Model output subareas are the scale for output of results



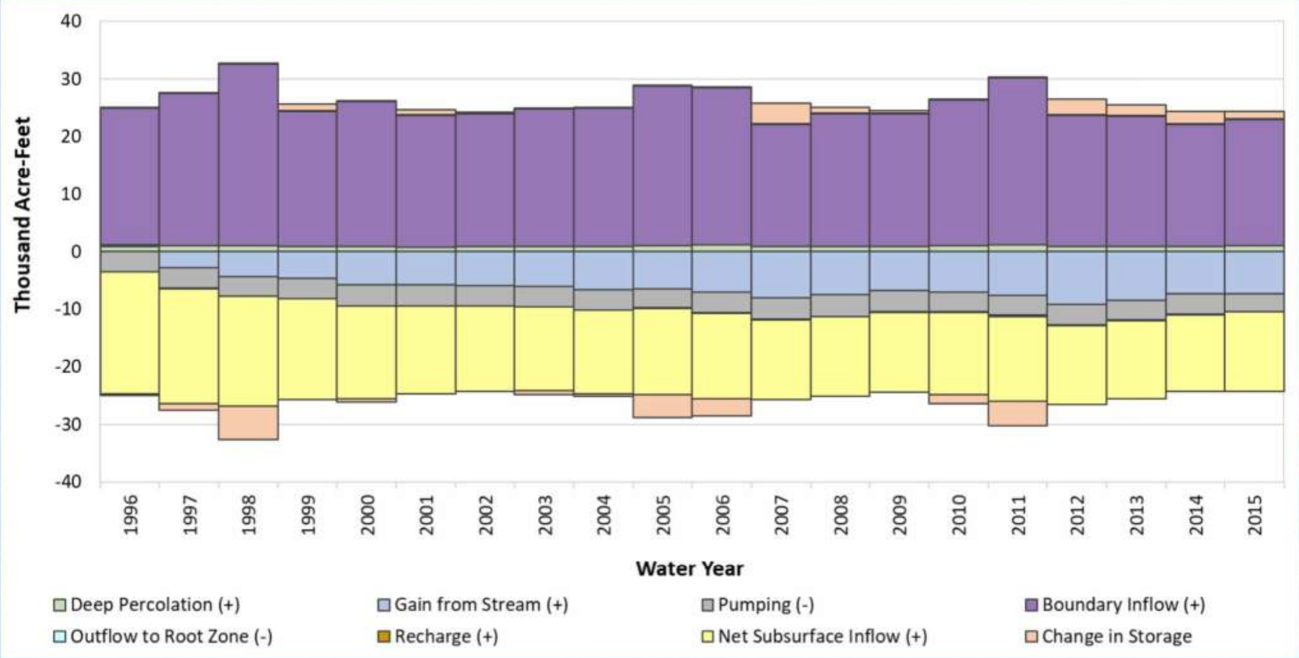
North Delta Subarea



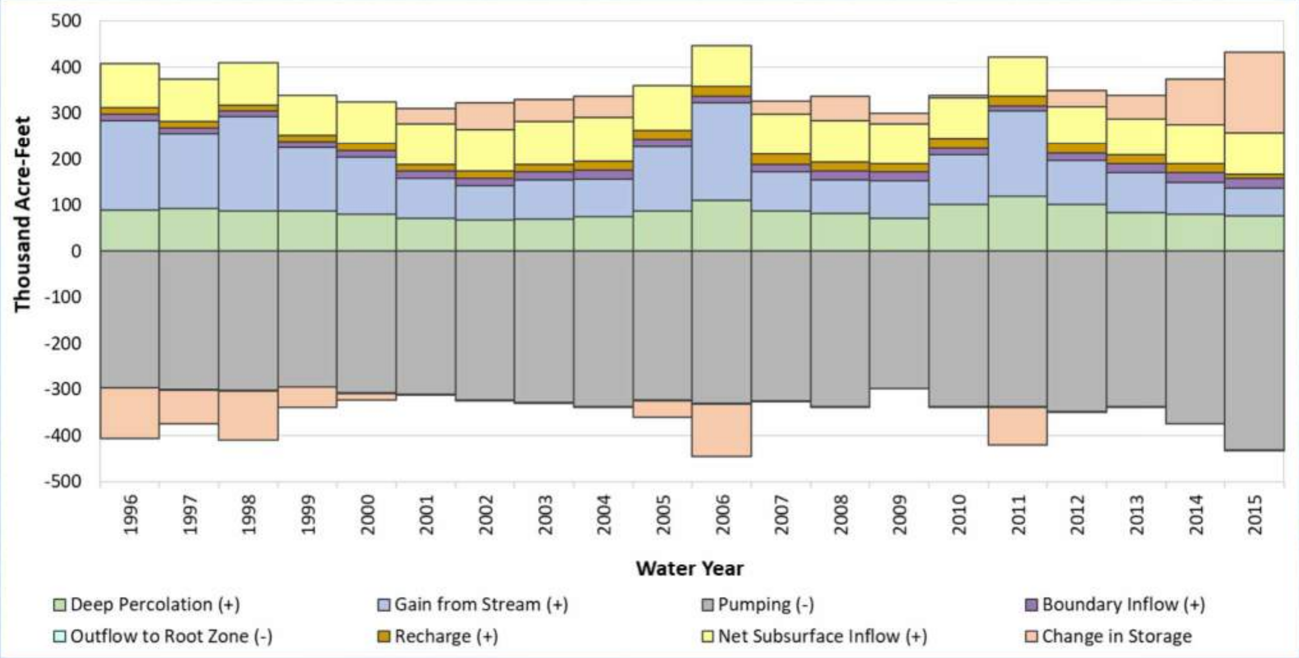
North Subarea



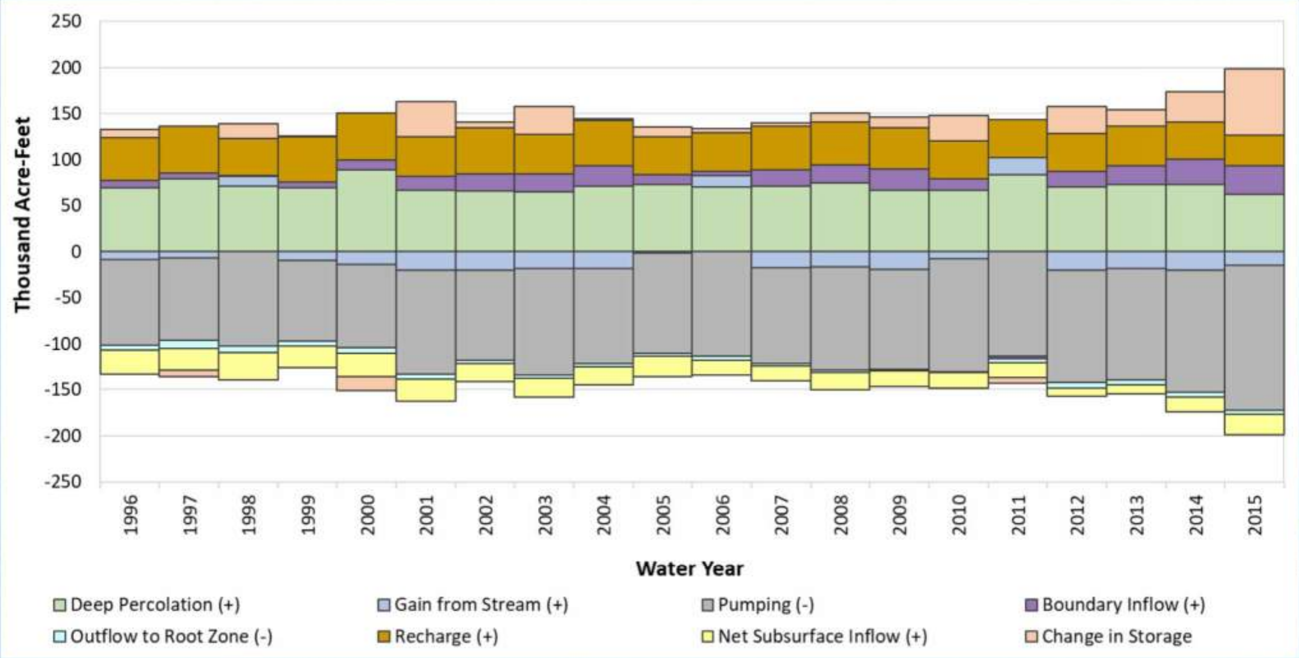
Calaveras Subarea



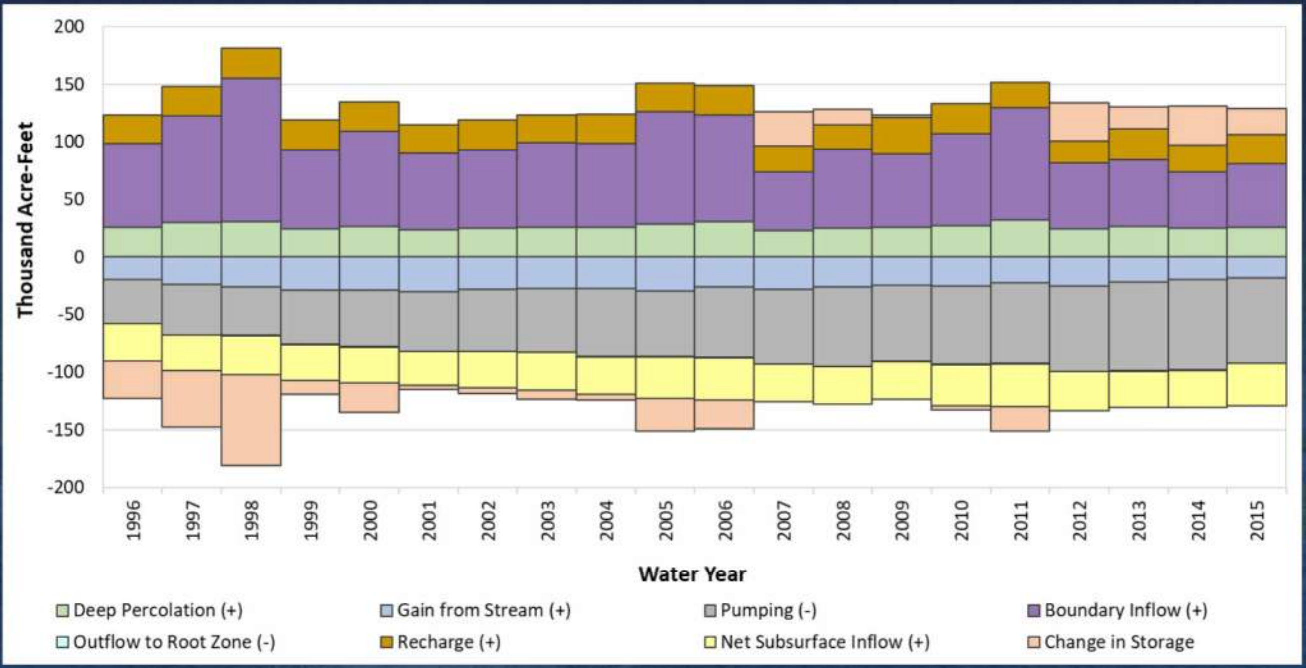
Central Subarea



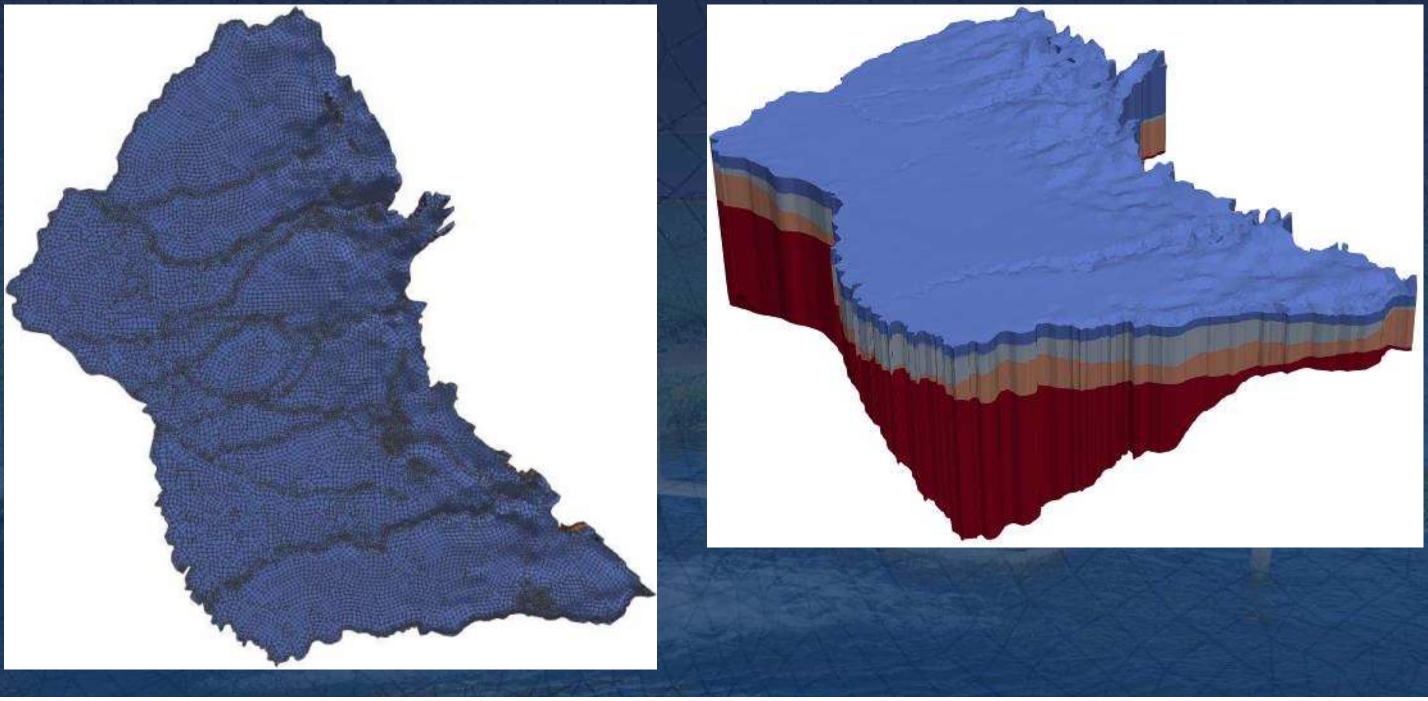
South Subarea



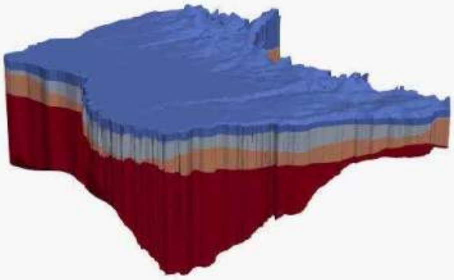
Stanislaus Subarea



Model Stratigraphy

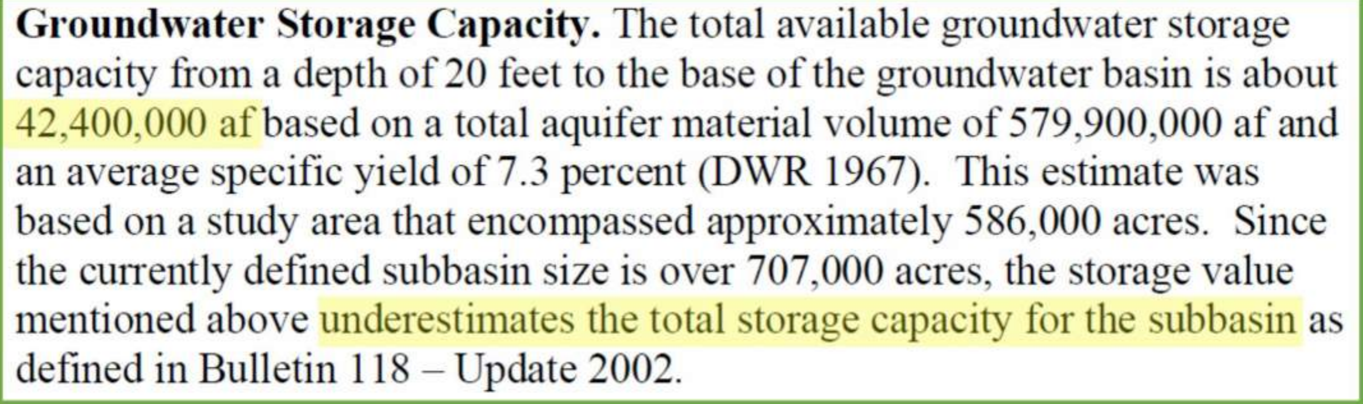


Model Stratigraphy: Rotation Around Model Edges



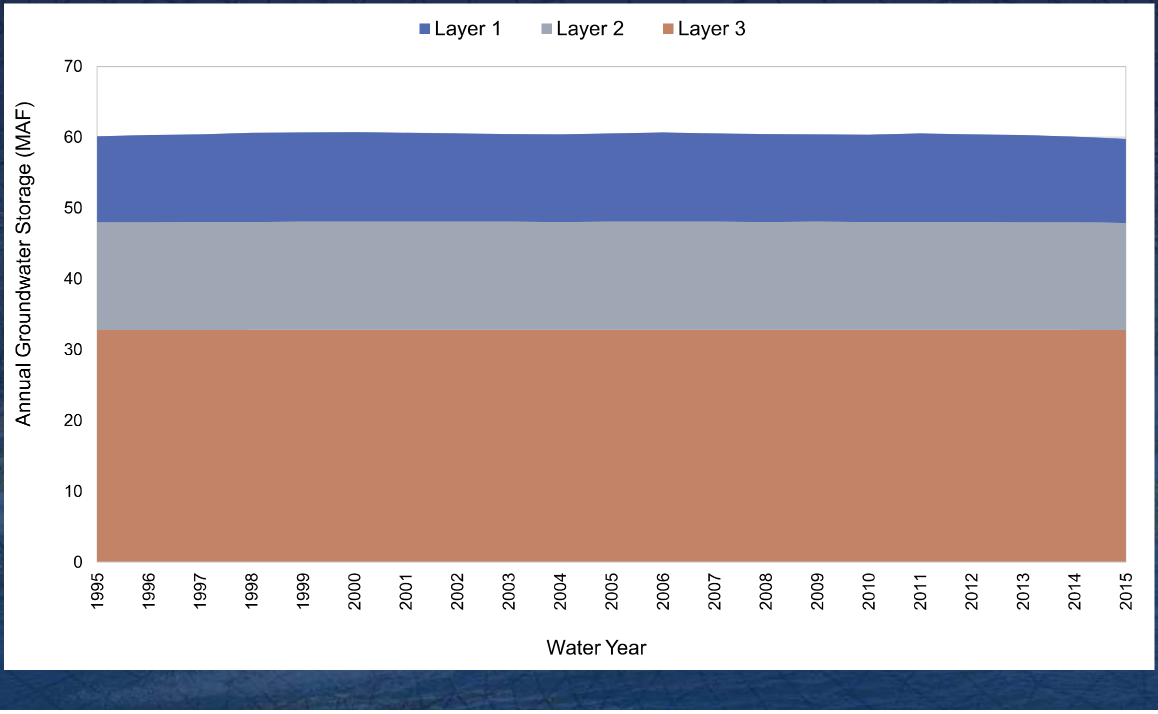
Estimates of Groundwater Storage

Bulletin 118 (1/20/2006)

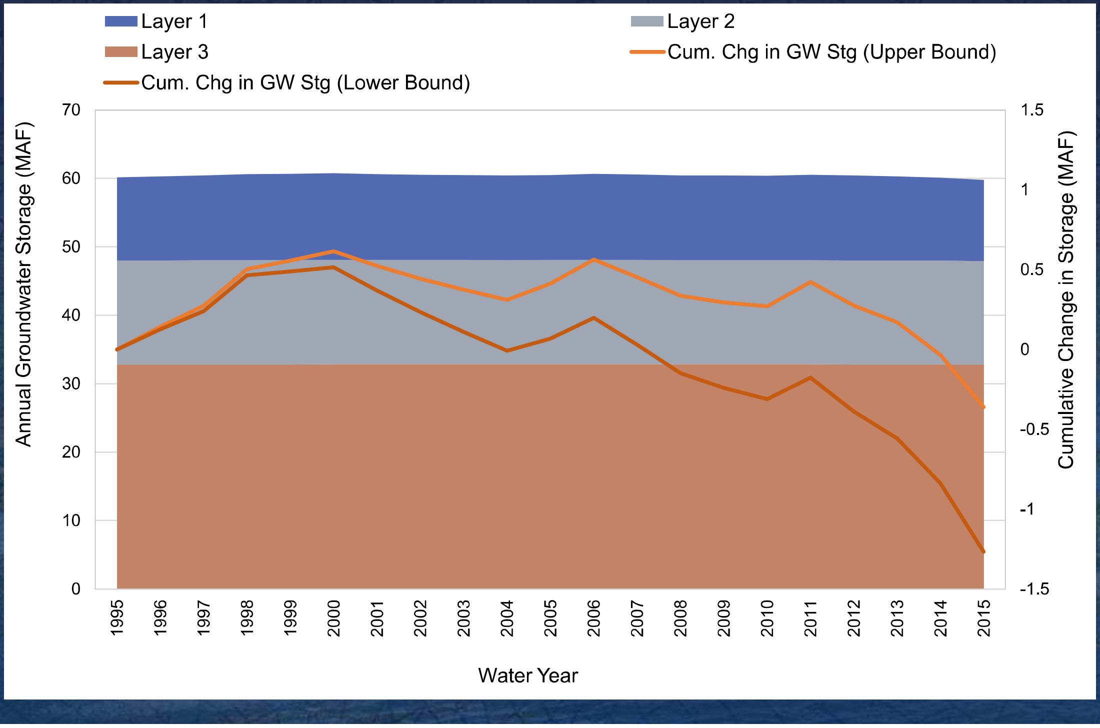


Groundwater Storage Capacity. The total available groundwater storage capacity from a depth of 20 feet to the base of the groundwater basin is about 42,400,000 af based on a total aquifer material volume of 579,900,000 af and an average specific yield of 7.3 percent (DWR 1967). This estimate was based on a study area that encompassed approximately 586,000 acres. Since the currently defined subbasin size is over 707,000 acres, the storage value mentioned above underestimates the total storage capacity for the subbasin as defined in Bulletin 118 – Update 2002.

Groundwater Storage



Change in Groundwater Storage



Next Steps

- Finalize Calibration
- Prepare Model Report
- Present Model Development and Results to ESJ GWA Board
- Support GSP Development
  - Develop Baseline Scenarios
    - Current Conditions
    - Future Conditions
  - Perform Sustainability Scenarios

APPENDIX B: ESJWRM IDC TECHNICAL MEMORANDUM

Technical Memorandum

SGMA Readiness Project

Subject:	**Eastern San Joaquin Water Resources Model** **Agricultural and Urban Demand Estimates (Task 2 Deliverable)**
Prepared For:	San Joaquin County
Prepared by:	Sara Miller
Reviewed by:	Ali Taghavi
Date:	2/1/2018
Reference:	0541002 Task 2

1 Introduction

The purpose of this Technical Memorandum is to document the data and information used in analyzing land surface processes, to briefly discuss the analytical tools used, and to present estimates of the agricultural and urban water use in the Eastern San Joaquin Groundwater Subbasin (ESJ Subbasin) as part of the development of the Eastern San Joaquin Water Resources Model (ESJWRM).

The IWFM Demand Calculator (IDC) (Dogrul et al., 2017) is used to estimate the agricultural and urban water use in the ESJ Subbasin portion of ESJWRM. IDC, the stand-alone version of the Integrated Water Flow Model's (IWFM) root zone component, calculates agricultural and urban water demands with major inputs including climate conditions, soil parameters, and land use types and distribution. The hydrologic period of the ESJWRM spans from October 1994 though September 2015 and covers water years 1995 through 2015.

The ESJWRM boundaries include the ESJ Subbasin (primary model area), as well as the Cosumnes Subbasin to the north and the Modesto Subbasin to the south. The model network is a Finite Element based grid that contains 16,054 elements and 15,302 nodes. The model elements are grouped into 20 model subregions that are used to organize input data for the model and to report standard model output water budgets (Figure 1). These subregions are aggregated into 8 larger units (model subareas) used to output model results for basin-scale planning (Figure 2). ESJ Subbasin, the primary model area, is made up of 18 subregions and is the focus of this Technical Memorandum.

2 Technical Review and Oversight

The development of the ESJWRM, including the development and calibration of IDC, is taking place in an open and transparent process. The Eastern San Joaquin County Groundwater Basin Authority (GBA) was the organizational structure for model development coordination before the creation of the Eastern San Joaquin Groundwater Authority (GWA). The GBA's Ad Hoc Technical Review Committee was the forum to review model input data and assumptions, as well as calibration results. The monthly committee meetings were open to all interested parties and generally consisted of technical representatives from local agencies, consultants with knowledge of the area, representatives for neighboring groundwater subbasins, DWR staff, and San Joaquin County personnel.

Local agencies with consistent representation included San Joaquin County, Woodbridge Irrigation District, City of Lodi, North San Joaquin Water Conservation District, Lockeford Community Services District, Calaveras County Water District, City of Stockton, Cal Water, Stockton East Water District, City of

Lathrop, City of Manteca, South San Joaquin Irrigation District, City of Escalon, Oakdale Irrigation District, and Stanislaus County.

3 Land Use

Spatial land use data was used to develop land use and crop acreages for each model element. Model element acreages were then aggregated by subregion for reporting and verification purposes.

The Department of Water Resources (DWR) conducts periodic land use surveys for each county that include over 70 different crop categories, as well as urban and native vegetation (DWR, 1993-2000). DWR land use surveys by county were merged and assumed to represent water year 1995 in the model. The surveys used include:

1. San Joaquin County (1996)
2. Sacramento County (1993)
3. Amador County (1997)
4. Calaveras County (2000)
5. Stanislaus County (1996)

Data for water years 2007 through 2015 are from the United States Department of Agriculture's remote sensing CropScape data (USDA NASS, 2007-2015). CropScape includes 256 land use categories that come from annual satellite imagery collected during the growing season on 30 meter by 30 meter pixels. Based on reports on the CropScape website, the level of accuracy for this data is about 85-97% for crop-specific land cover categories. Although this level of accuracy is high, the accuracy varies depending on many factors, including the time of the satellite image, growing season timing, cloud cover, type of crop, and maturity state of the crop.

DWR retained LandIQ, LLC to develop a statewide assessment of agricultural land use in summer 2014. LandIQ used remote sensing methods to collect and process the data, which was then ground truthed for a reported overall accuracy of 96.6% (DWR, 2014). In ESJWRM, this data was broadly used as verification of CropScape 2014 data and, in a few specific cases, as replacement or enhancement of the CropScape data.

Local data and knowledge was also utilized to refine and correct, as needed, the cropping acreages developed based on the DWR land use surveys and CropScape years. ESJWRM includes 23 irrigated crop categories and 4 general land use categories. The irrigated crop categories were combined into 6 high-level groupings of crops with similar water use or irrigation practices. Table 1 lists the land use categories.

To fill the gap between 1995 and 2007, all land use and crop categories were interpolated at the spatial resolution level of the model element. Thus, the geographic distribution of interpolated land use and cropping patterns are honored. Adjustments were made, as needed, at the element level to ensure that the land use and cropping pattern trends over time are reflective of local data. These adjustments were mostly based on local knowledge and information received from various entities, including irrigation districts, water districts, and municipalities.

Figure 3 and Figure 4 show the spatial distribution of the major land use categories in the ESJ Subbasin. Figure 5 shows the annual trends of land use categories in the ESJ Subbasin.

Figure 6, Figure 7, and Figure 8 show the spatial distribution of the irrigated crops for 1995, 2014, and 2015. Figure 9a-9m show the annual cropping patterns, by high level categories, for the ESJ Subbasin and those major model input subregions that are not predominantly urban centers (i.e., all subregions in the primary model area except subregions 3, 6, 9, 10, 12, and 16).

Table 1: Land Use Categories

Land Use Type	Model Category	Grouped Categories
Irrigated Crops	Almonds Cherries Citrus & Subtropical Other Orchard Pistachios Walnuts	Fruit and Nut Trees
	Vineyards	Vineyards
	Alfalfa Pasture	Alfalfa and Irrigated Pasture
	Grain	Grain
	Corn Cotton Dry Beans Field Crops Safflower Sugar Beets	Field Crops
	Cucurbits Onion & Garlic Potatoes Tomato Fresh Tomato Processing Truck Crops	Truck Crops
	Rice	Rice
Other Land Use	Urban Landscape Water Surface Riparian Vegetation Native Vegetation	

4 Urban Demand

IDC calculates urban demand based on per capita water use, population, and the breakdown of indoor versus outdoor water use by month. Figure 10 shows the annual population trends for each urban center. Figure 11 shows the annual per capita water use values of these urban centers used in the calculation of urban water demand. Figure 12a-12g show the model estimated annual urban demand for predominantly urban subregions and the total ESJ Subbasin area.

Population and per capita water use for the major urban areas were largely provided directly by the urban areas or were contained in Urban Water Management Plans (UWMPs). Additional annual population, including an estimate for rural urban areas, came from the United States Census Bureau and the California Department of Finance. Monthly per capita water use, commonly reported in gallons per capita per day (GPCD), was generally estimated for each urban entity using the annual population and monthly urban water use (provided by cities based on water delivery records). To estimate the urban water demand of rural domestic water areas, the average major urban area GPCD was combined with the estimated rural population.

It was assumed that an annual average of 60% of urban water was used indoors and 40% was used outdoors. The monthly fractions entered into the model had the majority of urban water demand due to indoor activities from November through March and up to a maximum of 60% of urban water used outdoors for the remainder of the year.

The indoor/outdoor breakdown received concurrence from the urban water providers who attended the Ad Hoc Technical Review Committee meetings. Population and per capita water use data were reviewed by the major urban areas and confirmed at the meetings (pers. comm. Kathryn Garcia, Andrew Richle, Michael Bolzowski, Greg Gibson, and Elba Mijango).

5 Agricultural Demand

IDC estimates agricultural water demand based on model input data for evapotranspiration (ET), monthly precipitation, return and reuse fractions, irrigation period, land use and cropping acreages, and soil properties (e.g., hydraulic conductivity, pore size distribution index, etc.). This data was compiled, analyzed, synthesized, and processed for input in ESJWRM.

The ET requirement is based on a variety of sources, including locally-developed data for the South San Joaquin Irrigation District and the Oakdale Irrigation District Agricultural Water Management Plans (AWMPs) (SJJID, 2015; OID, 2016) and averages for DWR’s CIMIS (California Irrigation Management Information System) Zone 12 developed using the METRIC methodology, which is a remote-sensing based technology to estimate crop actual ET. Based on discussions with locals (pers. comm. Jennifer Spaletta and Bryan Thoreson), deficit irrigation of vineyards was simulated in ESJWRM with reference to the growing season ET values in the Lodi area (Prichard). Figure 13 shows the range in annual evapotranspiration rates from the various sources for the 27 model land use categories.

Monthly rainfall data was derived from the PRISM (OSU, 1970-2015) database and mapped to the model element in order to preserve the spatial distribution of the monthly rainfall over the model hydrologic period of 1995 through 2015. Figure 14 shows the annual rainfall in the model area and the cumulative departure from mean, which is an indication of long-term rainfall trends in the area.

The soil properties included in the model for each element are field capacity, wilting point, total porosity, hydraulic conductivity, and pore size distribution index. The soil survey geographic (SSURGO) database was downloaded first from the Web Soil Survey and any gaps in data were filled in using the General Soil Map of the United States (STATSGO2). These spatial datasets were averaged over each model element using IWFM’s Soil Data Builder with GIS tool available at http://baydeltaoffice.water.ca.gov/modeling/hydrology/IWFM/SupportTools/index_SupportTools.cfm.

IDC was used to simulate the monthly agricultural demand estimates for each model element. The IDC model was calibrated to agricultural water use values reported by irrigation districts in their AWMPs and then checked against local data with input from irrigation district representatives and consultants (pers. comm. Doug Heberle, Jennifer Spaletta, Tom Flinn, Peter Martin, Cathy Lee, Manuel Verduzco, Sam Bologna, Bryan Thoreson, Emily Sheldon, Eric Thorburn, and Byron Clark). ESJWRM as a whole will undergo a more rigorous calibration process comparing model streamflow and groundwater levels to actual observed data.

The calibrated IDC was used to estimate monthly agricultural water demand at each model element during the model hydrologic period. The element-level estimates were then aggregated to report the information for each model subregion. Figure 15a-15n show the agricultural water demand, unit agricultural water use, and unit evapotranspiration of applied water (ETAW) estimates by the total ESJ Subbasin area and the subregions with irrigation districts who participated in the IDC development and calibration process.

The IDC model will be integrated with the comprehensive IWFM model, ESJWRM, to simulate the surface water and groundwater conditions in the ESJ Subbasin.

6 References

Department of Water Resources (DWR). Statewide Crop Mapping 2014. Downloaded for three groundwater subbasins in model area. https://gis.water.ca.gov/app/CADWRLandUseViewer/.

Department of Water Resources (DWR). Land Use Surveys. Downloaded various counties and years from 1993-2000. http://www.water.ca.gov/landwateruse/lusrvymain.cfm

Dogrul, Emin C., Tariq N. Kadir, and Charles F. Brush, August 2017. DWR Technical Memorandum: Theoretical Documentation and User's Manual for IWFM Demand Calculator (IDC-2015), Revision 63. Bay-Delta Office, California Department of Water Resources. http://baydeltaoffice. water.ca.gov/modeling/hydrology/IDC/IDC-2015/v2015_0_63/index_ IDCv2015_0_63.cfm.

Irrigation Training and Research Center (ITRC), California Polytechnic State University San Luis Obispo. California Evapotranspiration Data. CIMIS Zone 12, Water Balance Data, Sprinkler Irrigation, Typical Year. http://www.itrc.org/etdata/index.html.

Oakdale Irrigation District (OID), March 2016. 2015 Agricultural Water Management Plan. Prepared by Davids Engineering. http://www.water.ca.gov/wateruseefficiency/sb7/docs/2016/Oakdale%20ID%20201 5%20AWMP.pdf.

Oregon State University (OSU). PRISM Climate Group. Downloaded 1970-2015. http://prism.oregonstate.edu.

Prichard, Terry L. Winegrape Irrigation Scheduling Using Deficit Irrigation Techniques. University of California, Davis. http://ucanr.edu/sites/ce_san_joaquin/files/ 35706.pdf.

South San Joaquin Irrigation District (SSJID), December 2015. 2015 Agricultural Water Management Plan. Prepared by Davids Engineering. http://www.water.ca.gov/wateruseefficiency/sb7/docs/2015/ plans/SSJID%20AWMP%202015%20FINAL.pdf.

Web Soil Survey. Natural Resources Conservation Service, United States Department of Agriculture. https://websoilsurvey.nrcs.usda.gov/.

United States Department of Agriculture (USDA) National Agricultural Statistics Service (NASS). Cropland Data Layers. Downloaded 2007-2015. USDA-NASS, Washington, DC. https://nassgeodata.gmu.edu/CropScape/.

Figure 1: Model Subregions

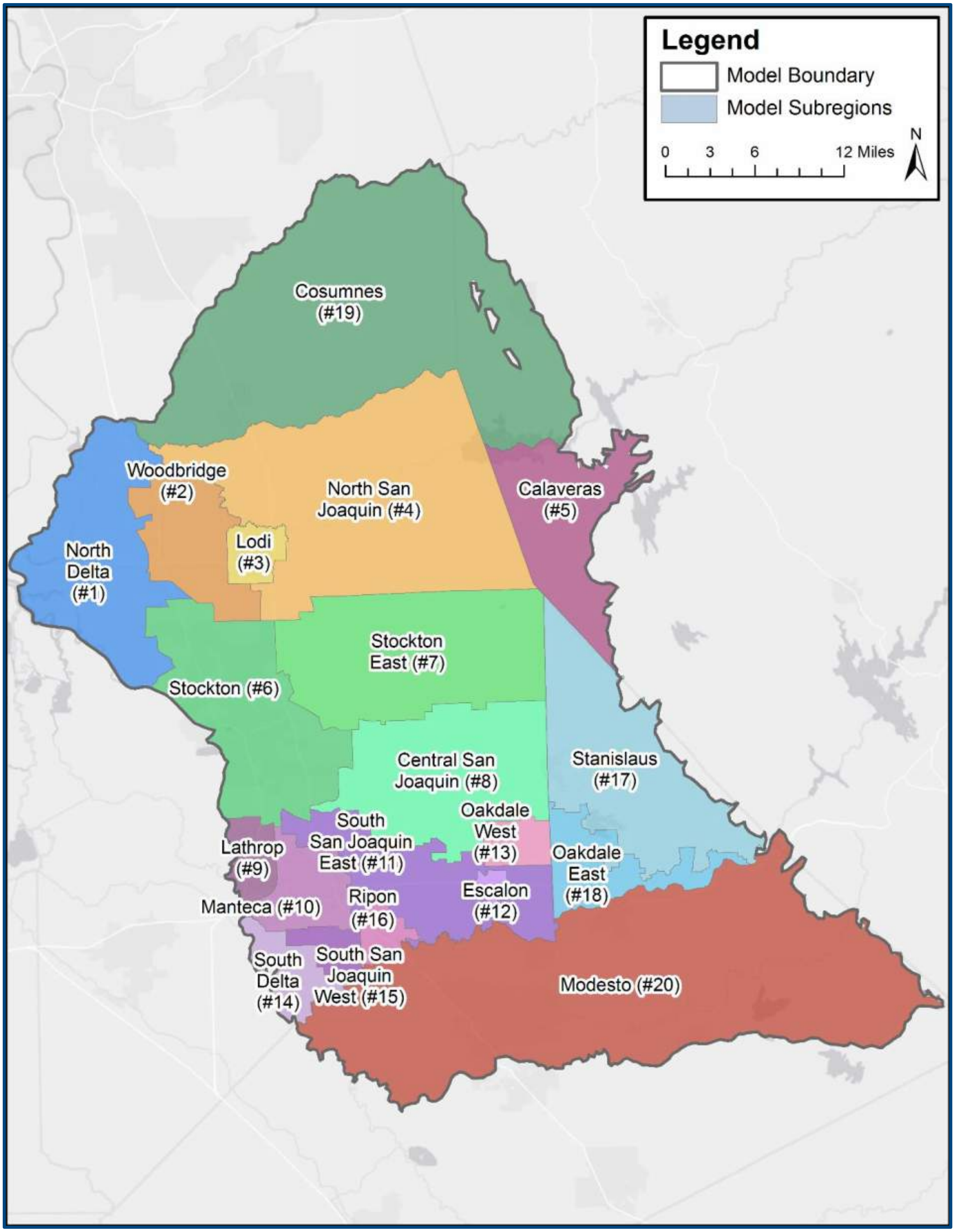


Figure 2: Model Subareas with Eastern San Joaquin Subbasin

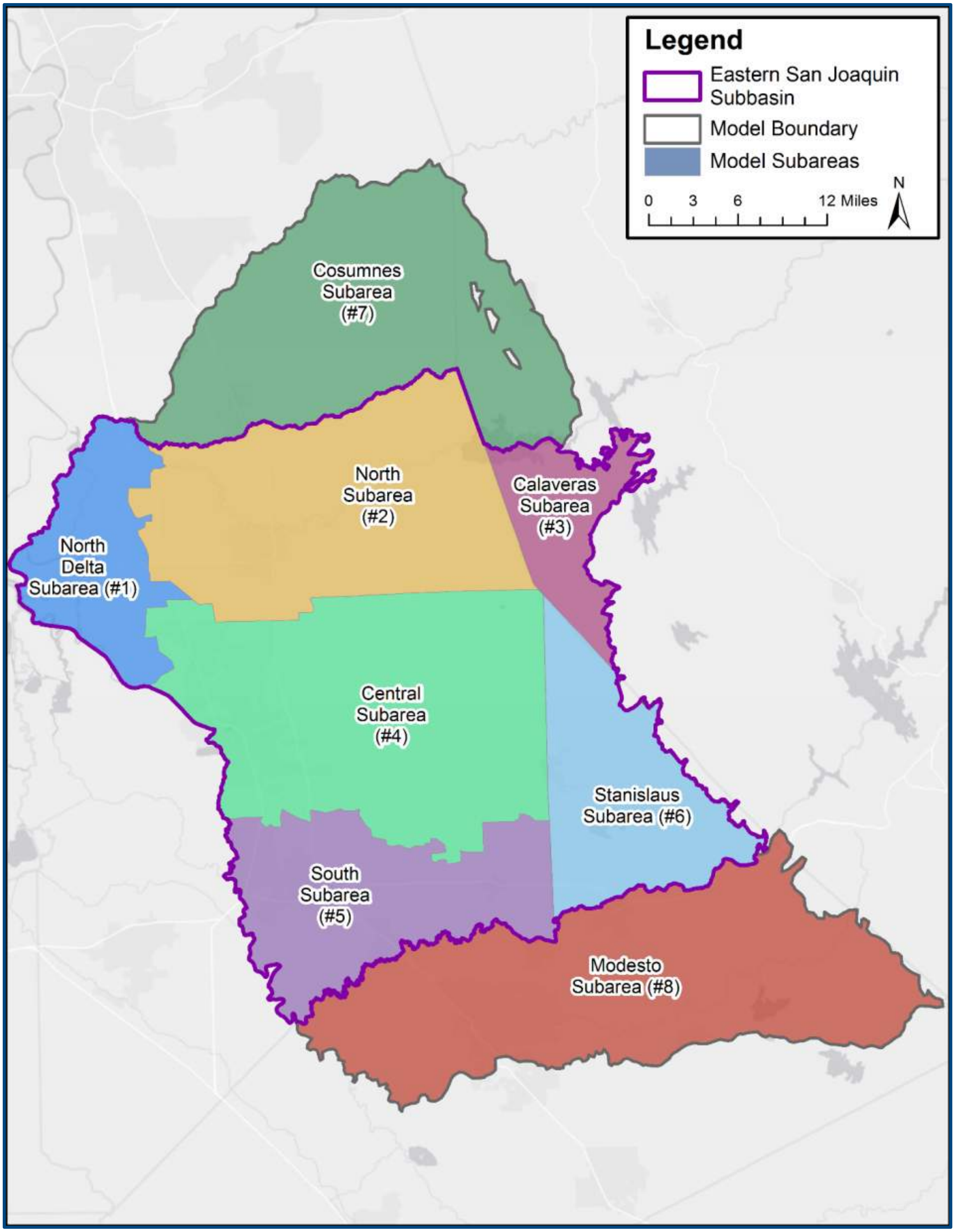


Figure 3: General Land Use in 1995 DWR Land Use Survey

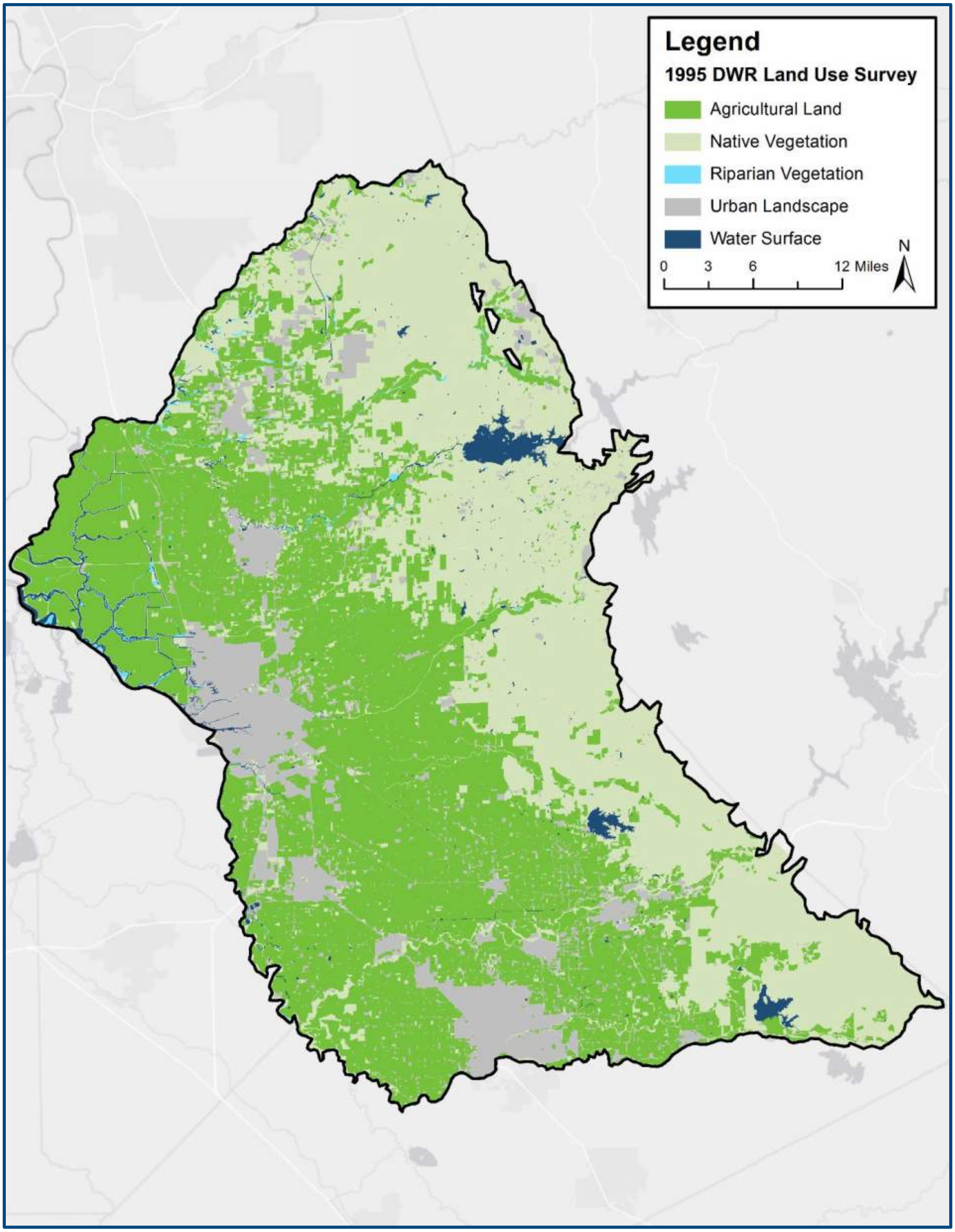


Figure 4: General Land Use in 2015 CropScape

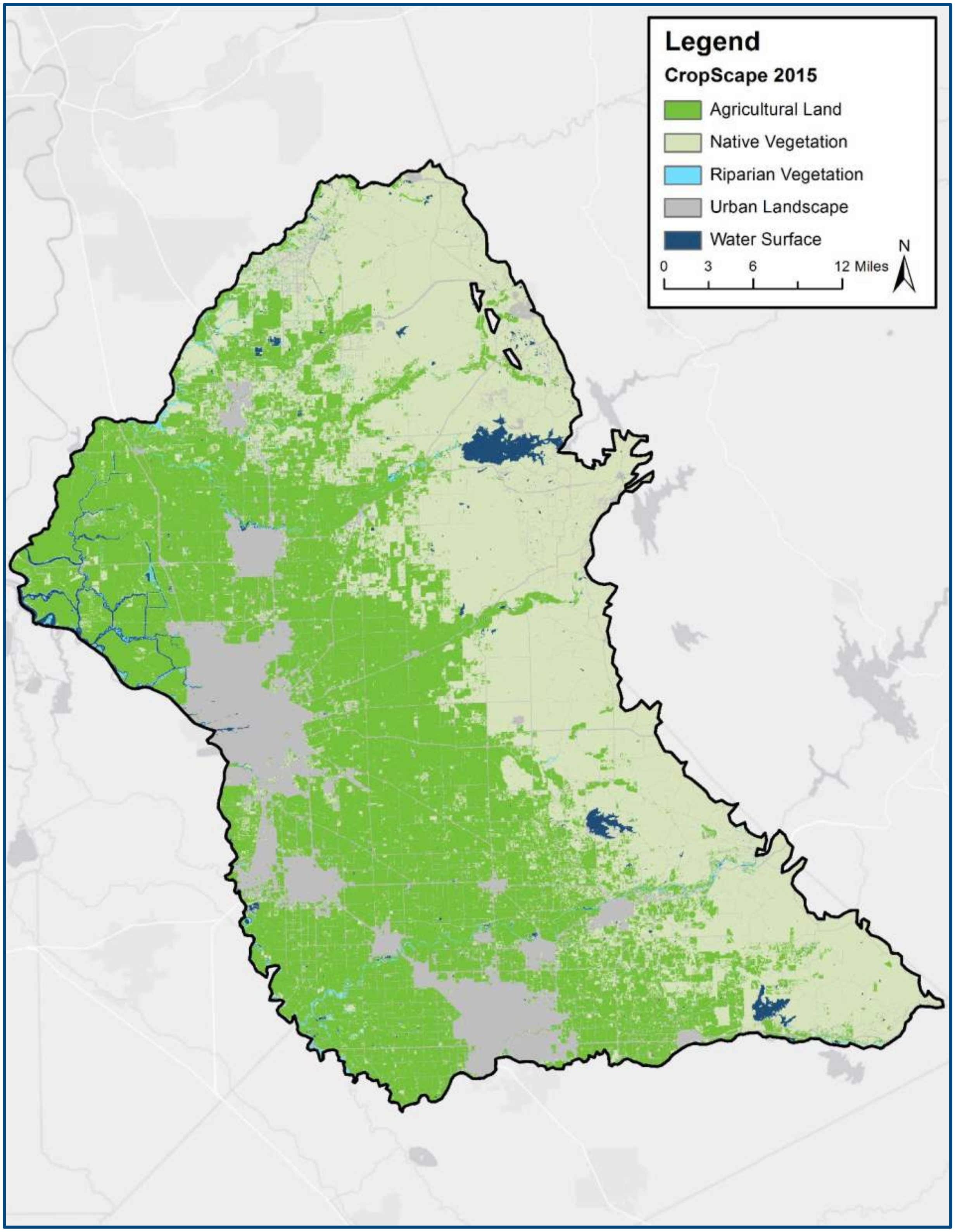


Figure 5: Eastern San Joaquin Subbasin General Land Use Acreages

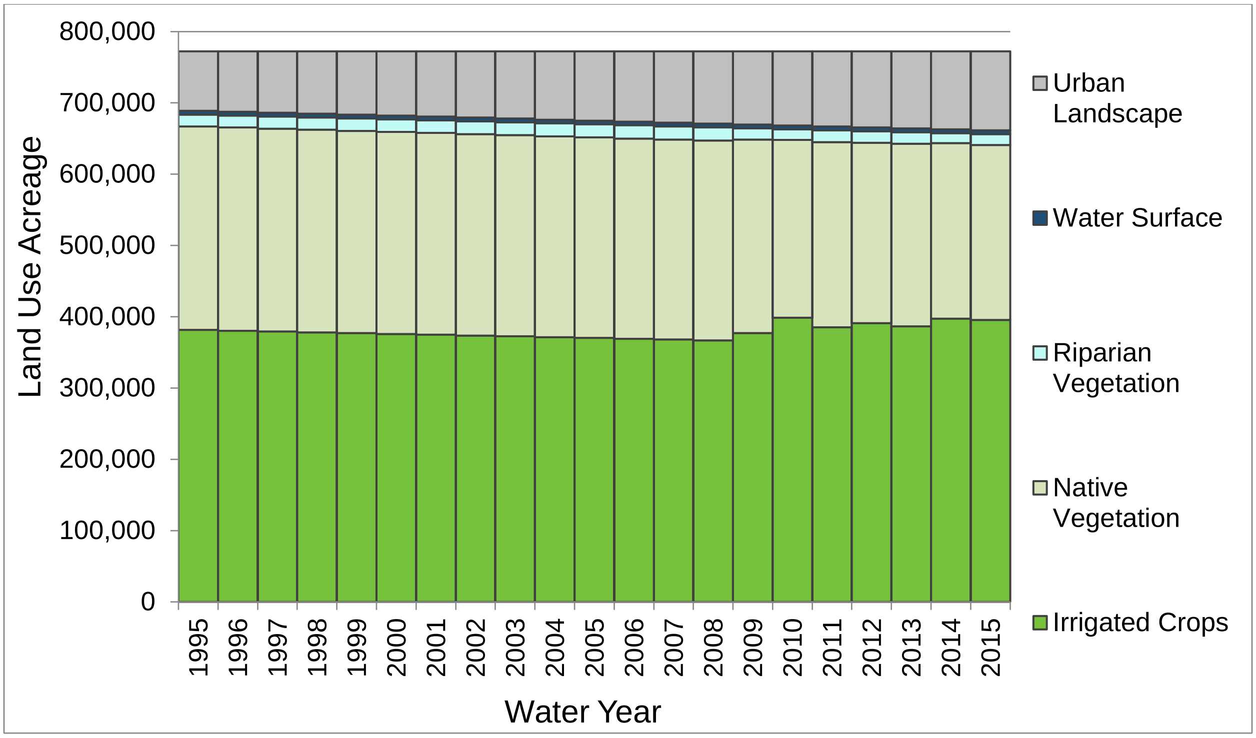


Figure 6: Cropping Pattern in 1995 DWR Land Use Survey

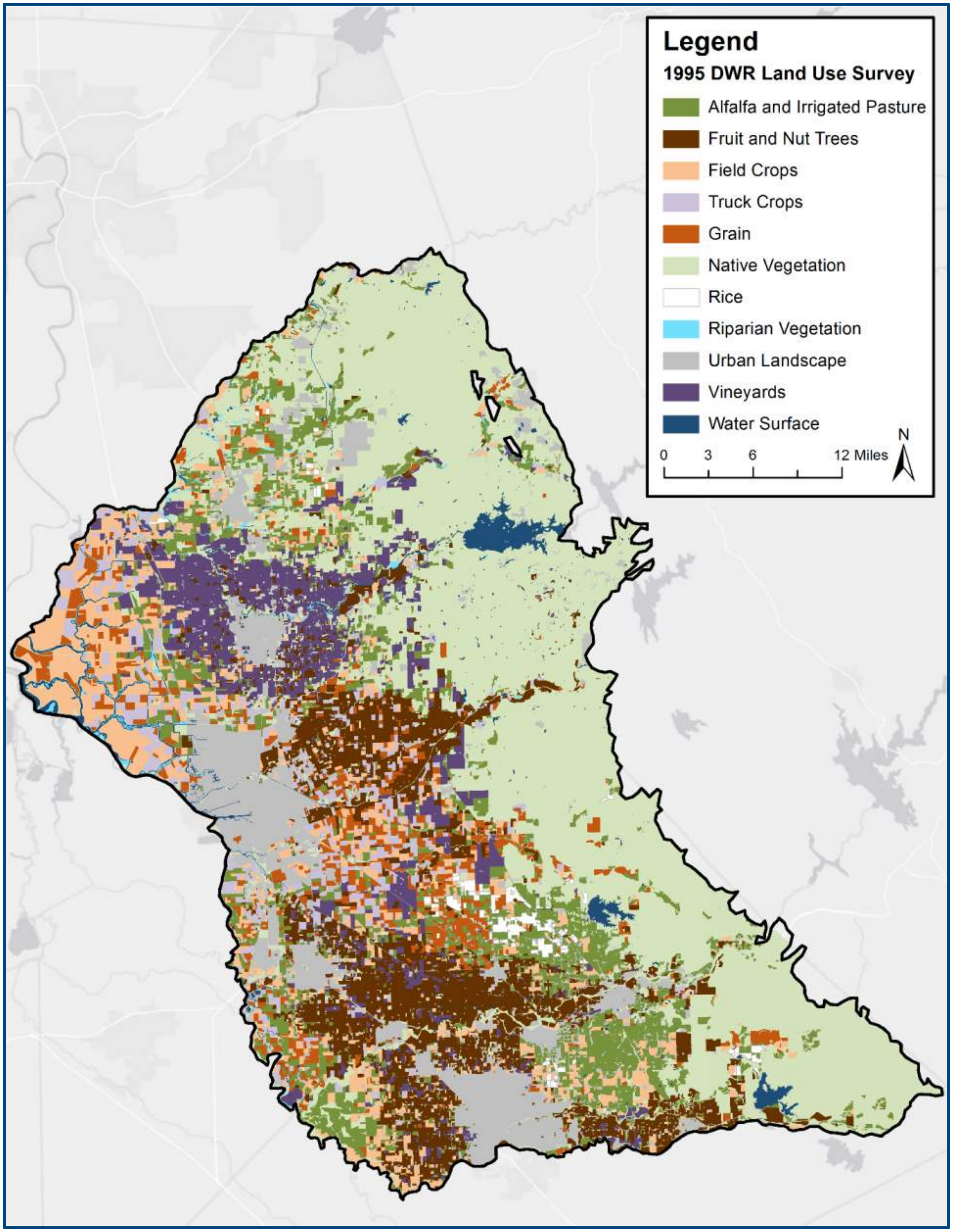


Figure 7: Cropping Pattern in 2014 LandIQ

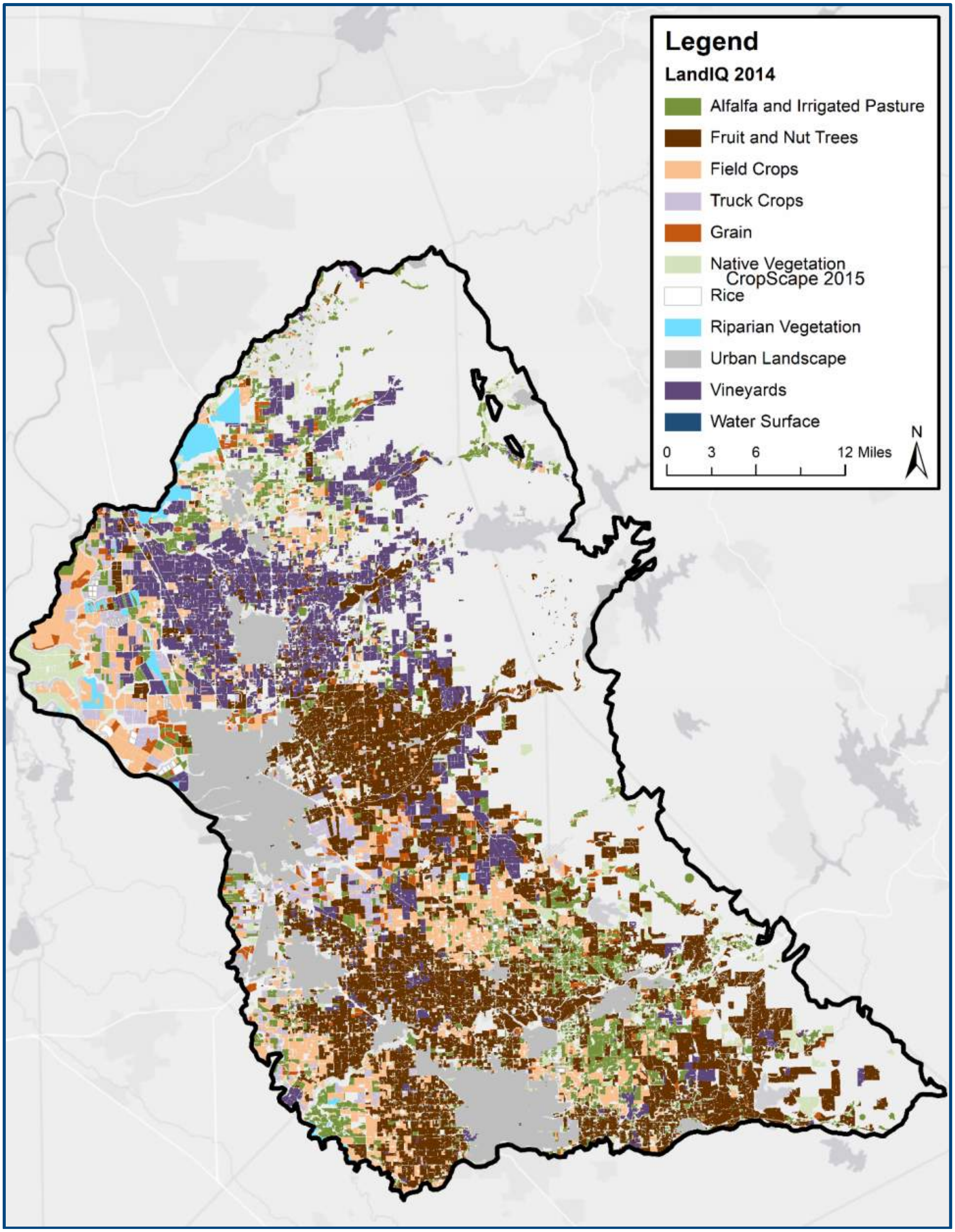


Figure 8: Cropping Pattern in 2015 CropScape

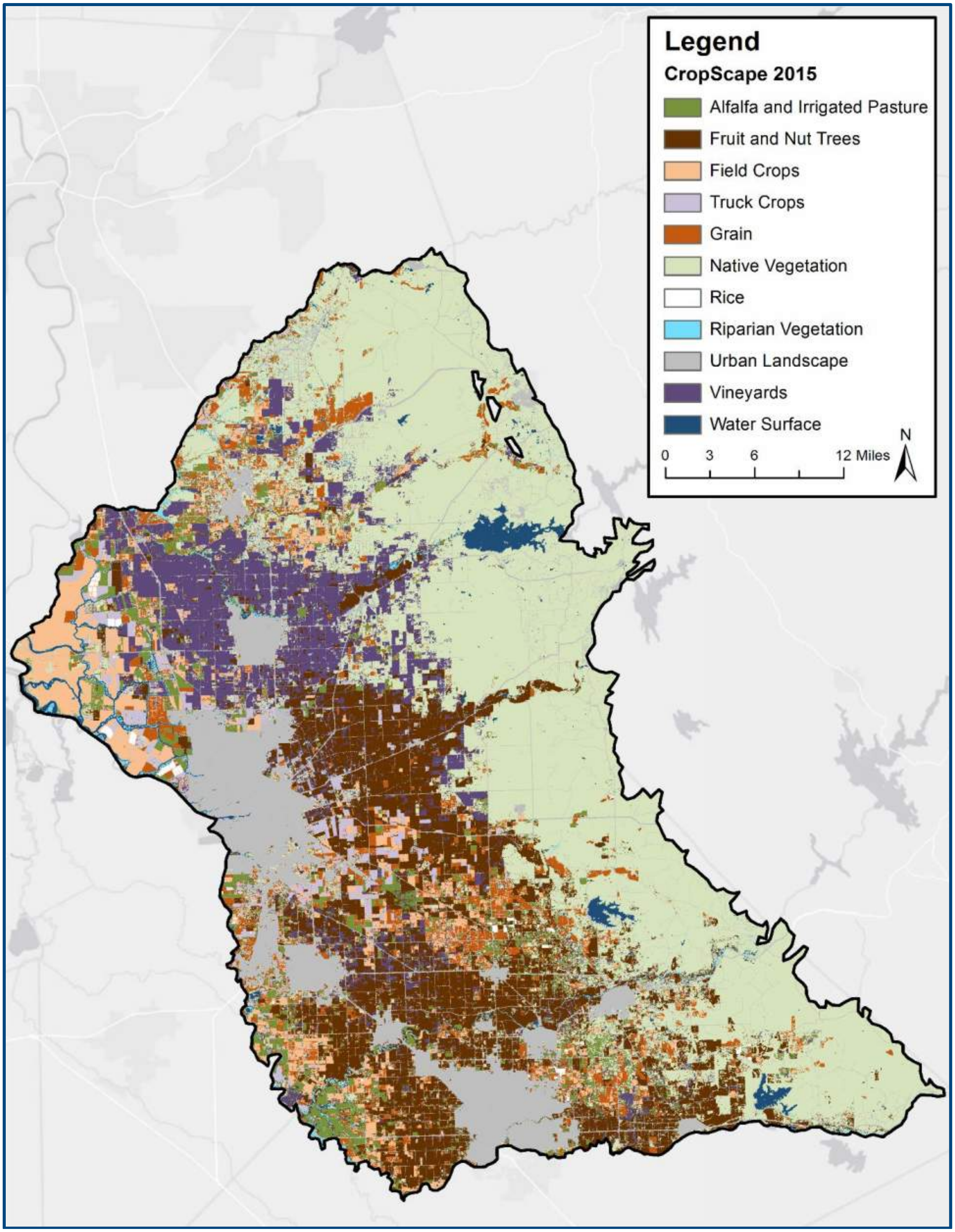


Figure 9a: Irrigated Crop Acreages- Eastern San Joaquin Subbasin

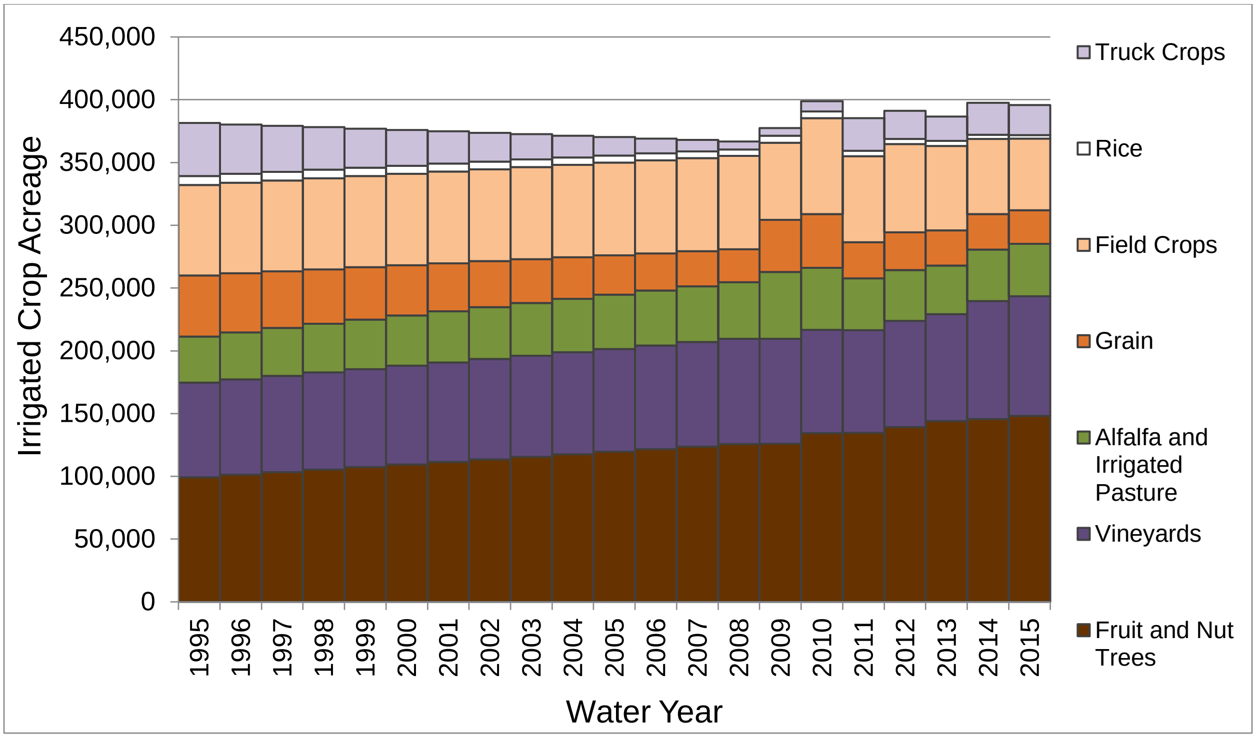


Figure 9b: Irrigated Crop Acreages- Subregion 1 (North Delta Subregion)

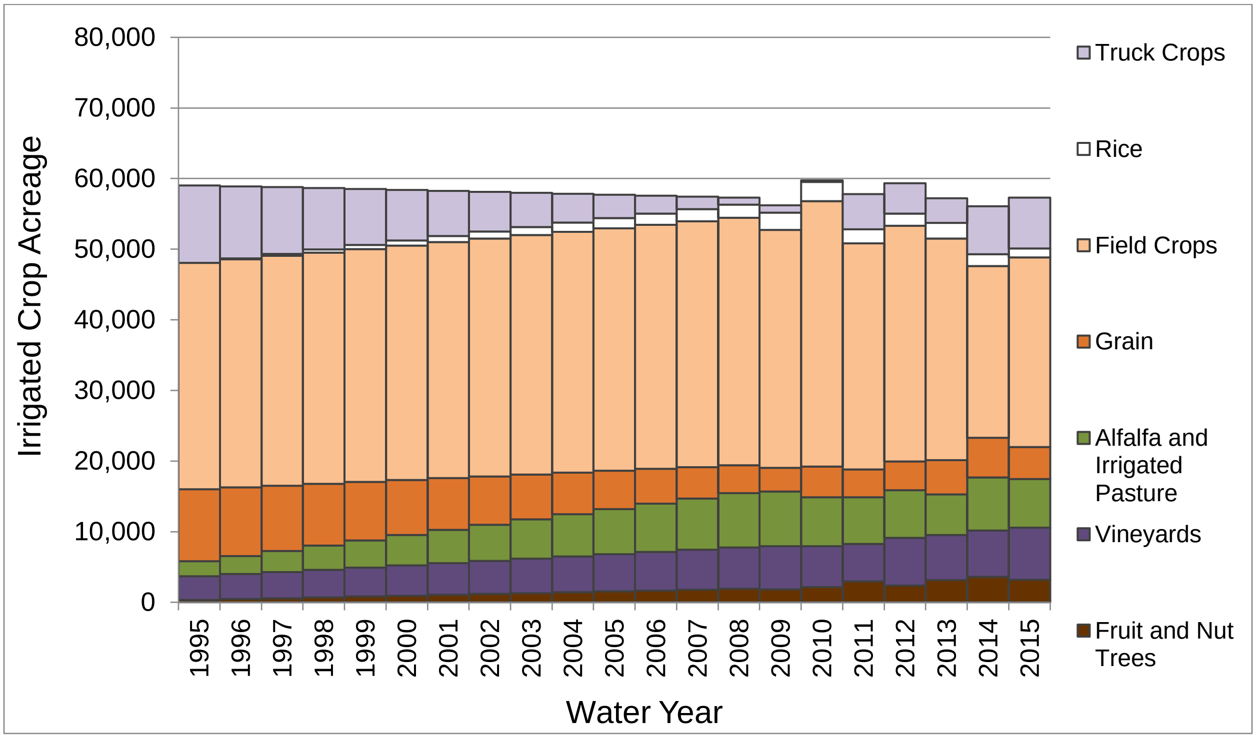


Figure 9c: Irrigated Crop Acreages- Subregion 2 (Woodbridge Subregion)

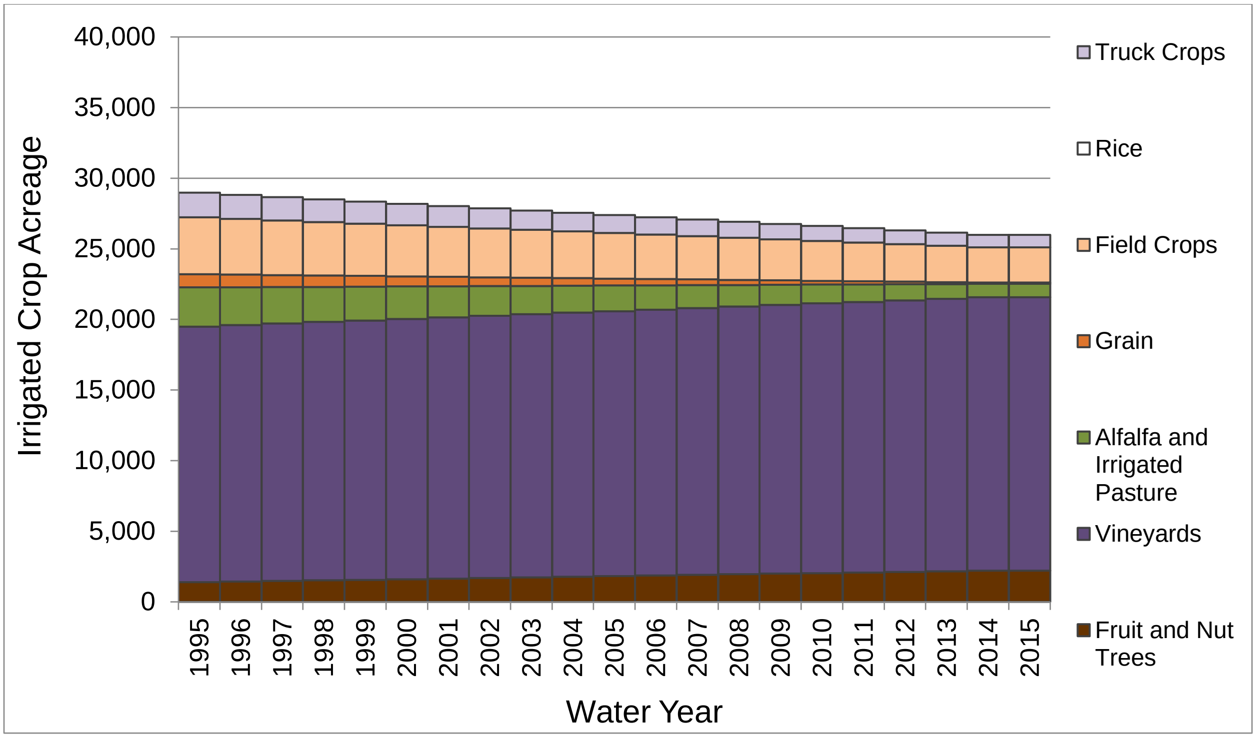


Figure 9d: Irrigated Crop Acreages- Subregion 4 (North San Joaquin Subregion)

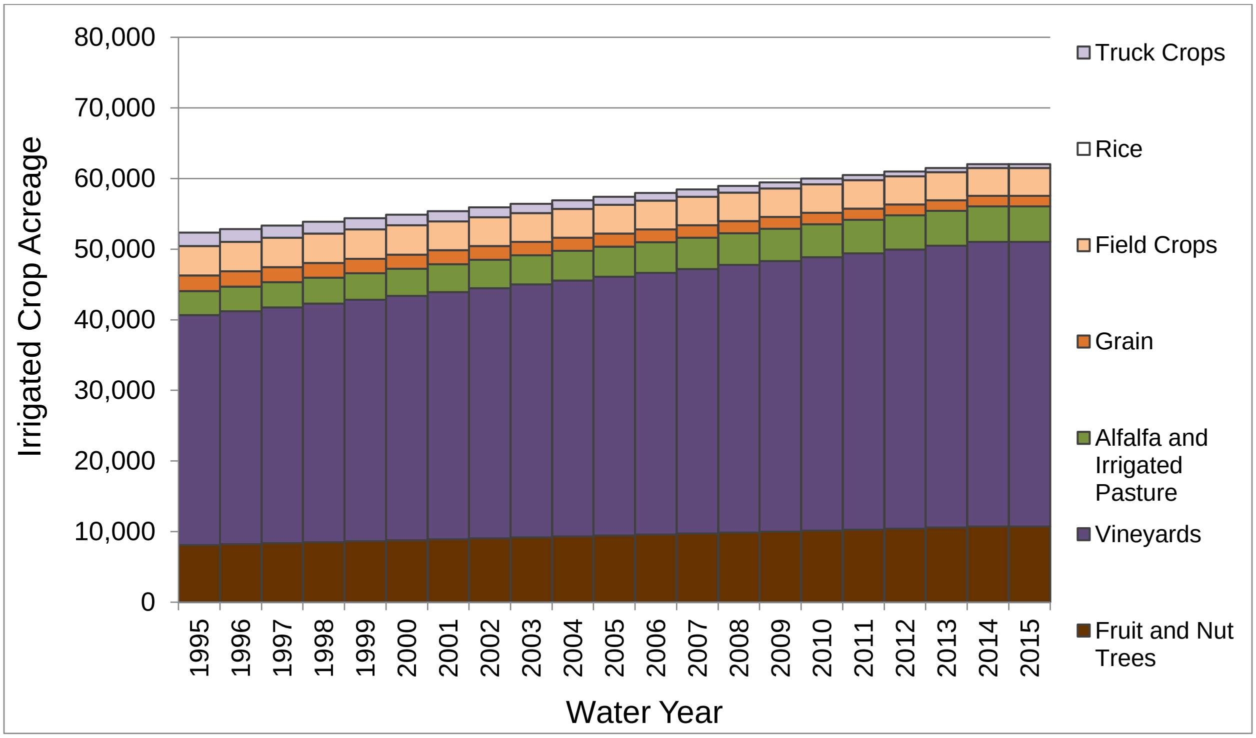


Figure 9e: Irrigated Crop Acreages- Subregion 5 (Calaveras Subregion)

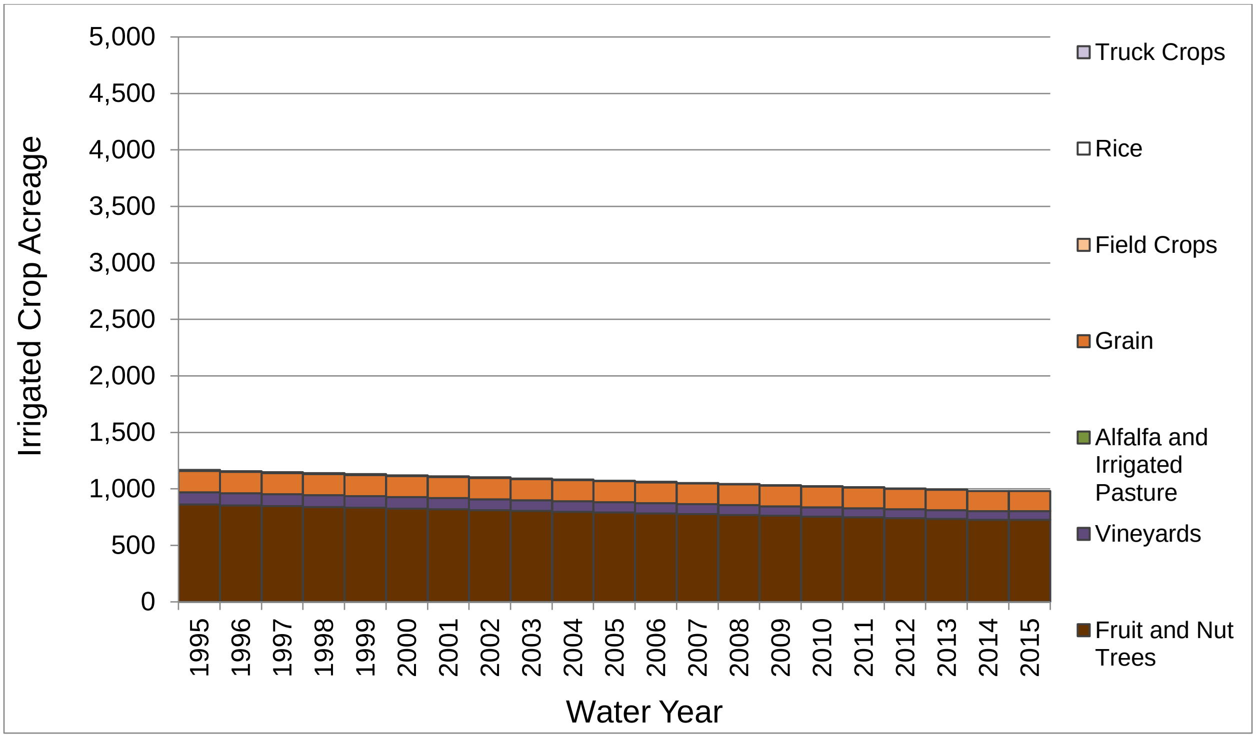


Figure 9f: Irrigated Crop Acreages- Subregion 7 (Stockton East Subregion)

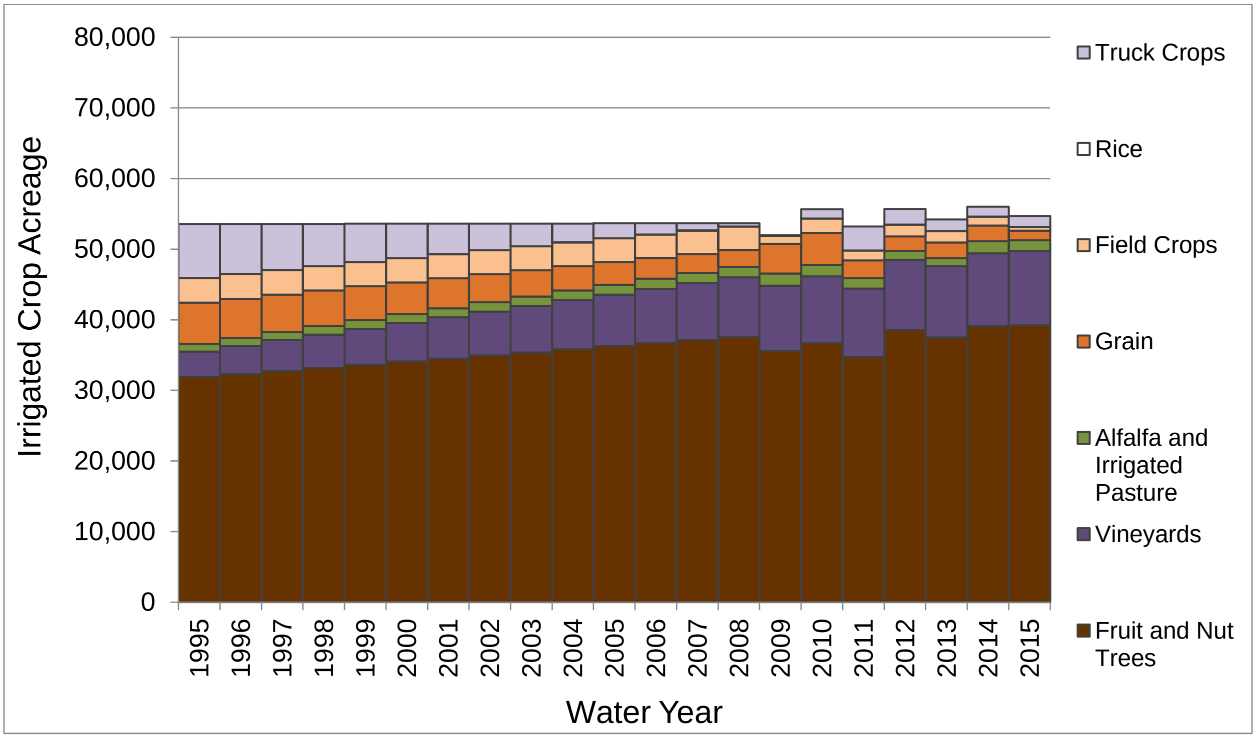


Figure 9g: Irrigated Crop Acreages- Subregion 8 (Central San Joaquin Subregion)

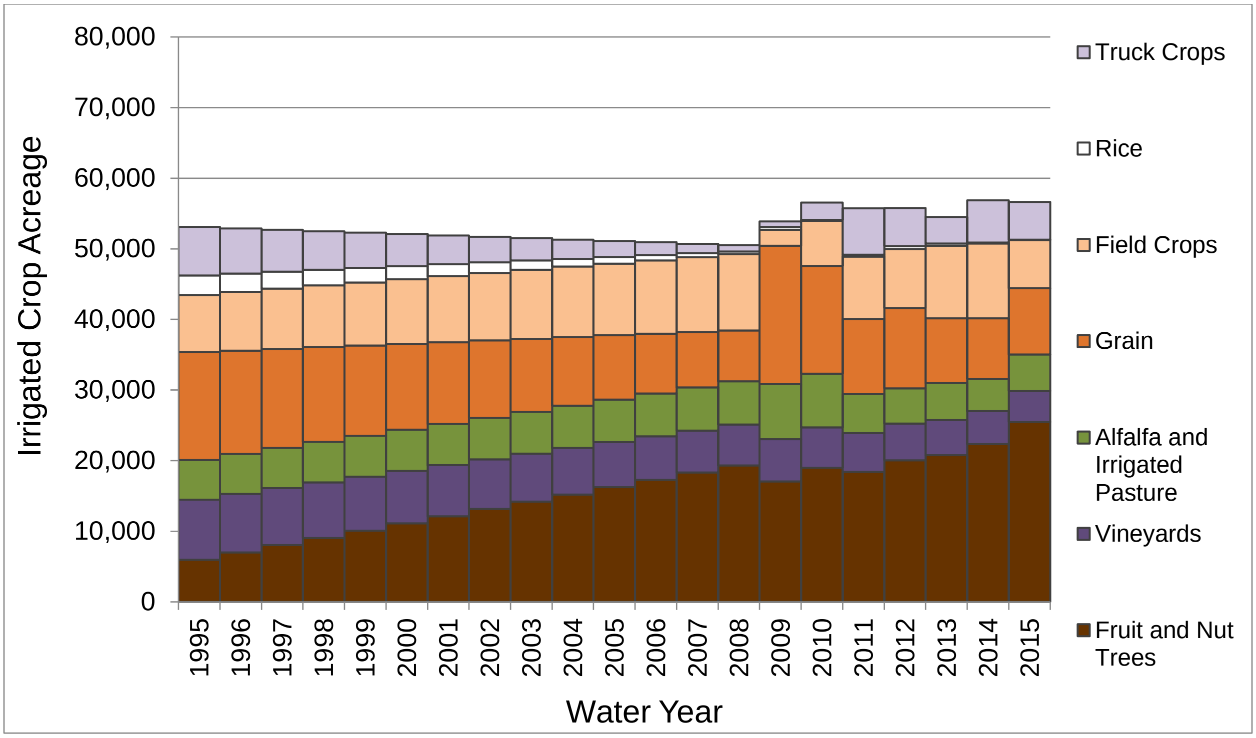


Figure 9h: Irrigated Crop Acreages- Subregion 11 (South San Joaquin East Subregion)

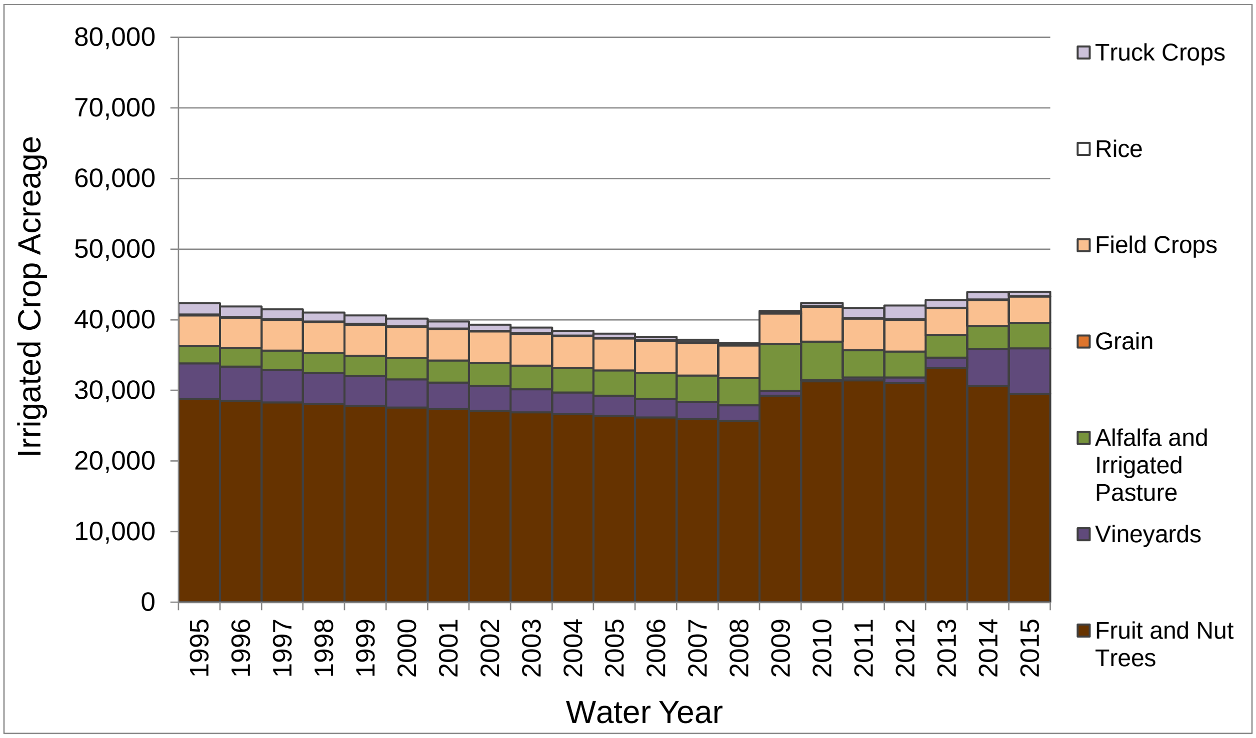


Figure 9i: Irrigated Crop Acreages- Subregion 13 (Oakdale West Subregion)

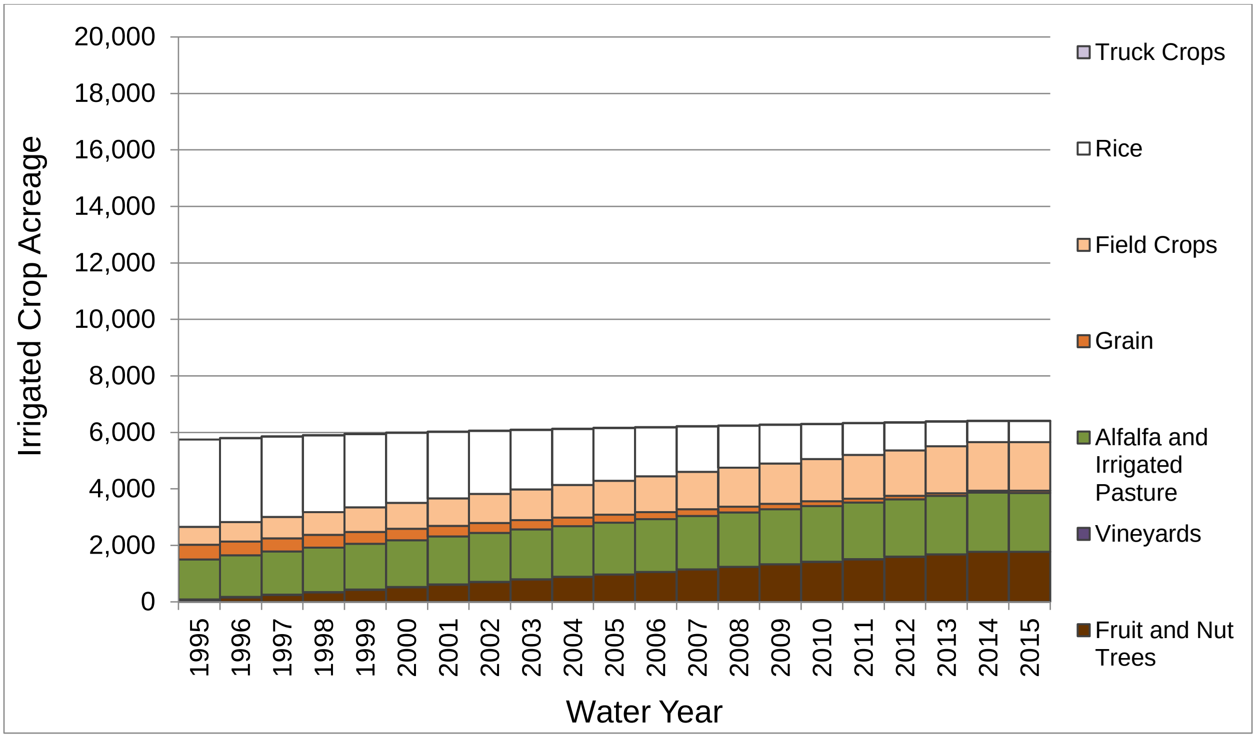


Figure 9j: Irrigated Crop Acreages- Subregion 14 (South Delta Subregion)

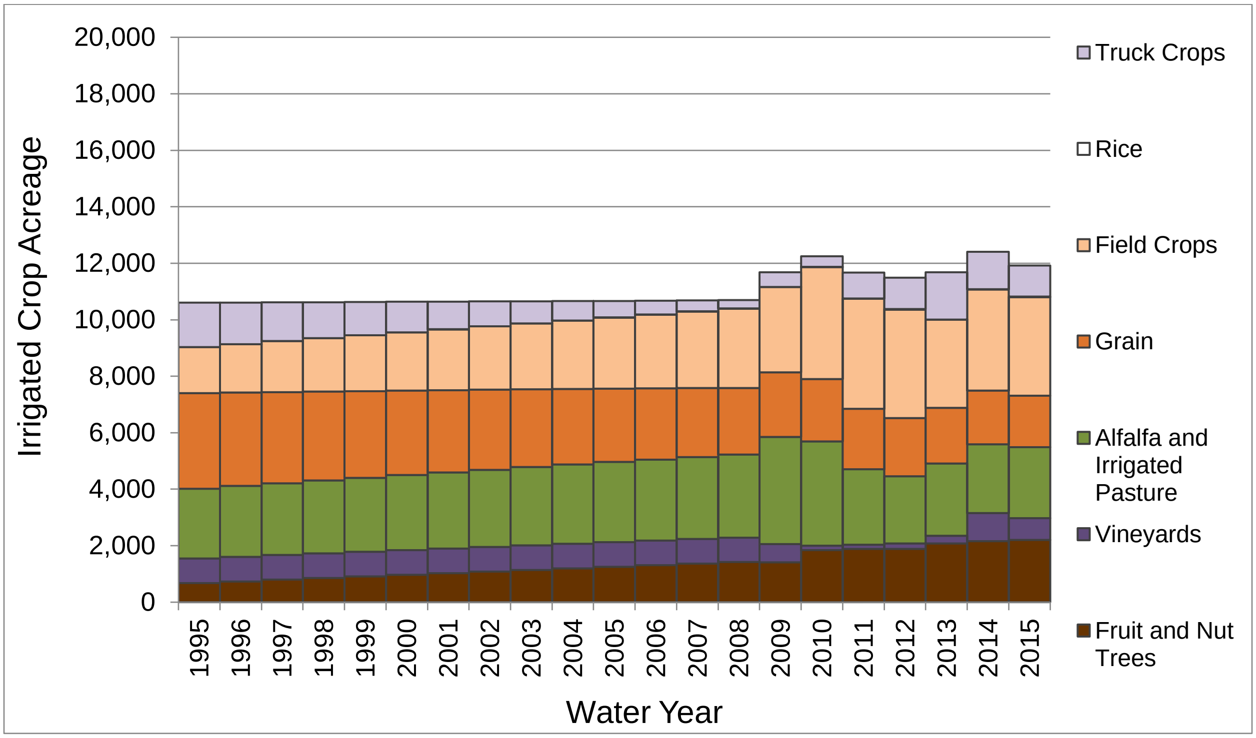


Figure 9k: Irrigated Crop Acreages- Subregion 15 (South San Joaquin West Subregion)

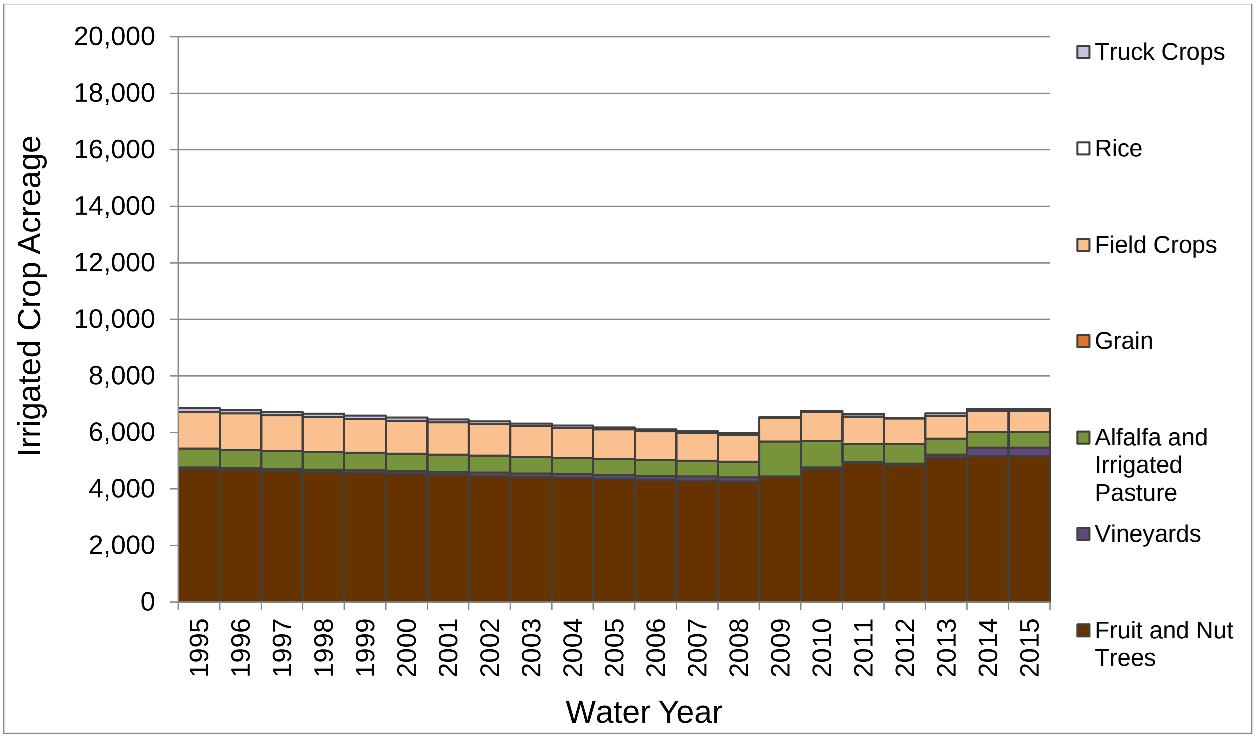


Figure 9l: Irrigated Crop Acreages- Subregion 17 (Stanislaus Subregion)

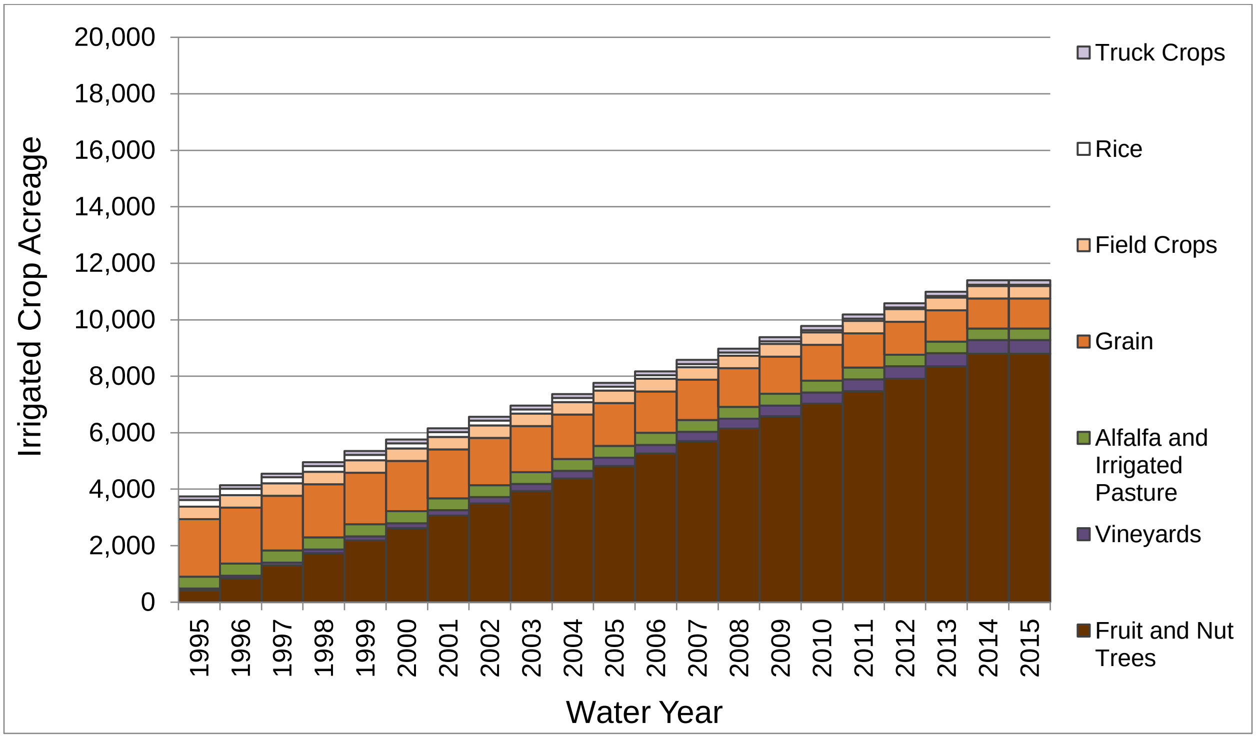


Figure 9m: Irrigated Crop Acreages- Subregion 18 (Oakdale East Subregion)

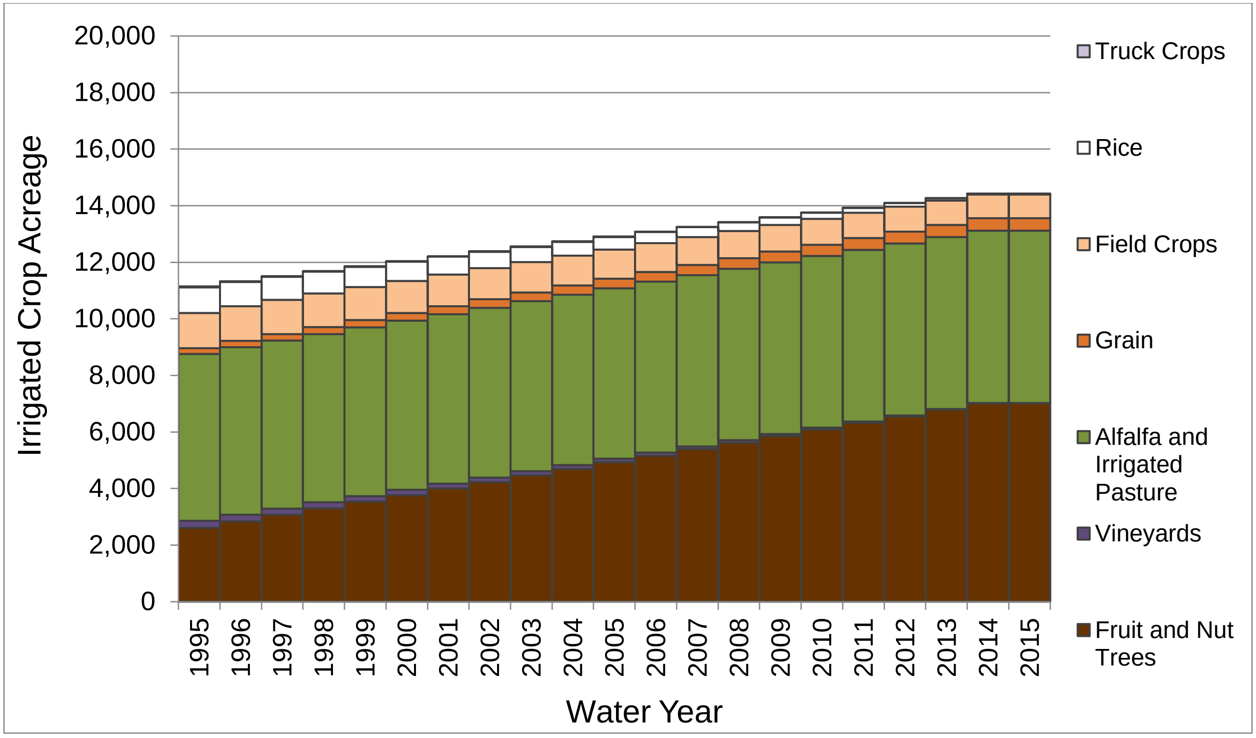


Figure 10: Urban Population Centers in Eastern San Joaquin Subbasin

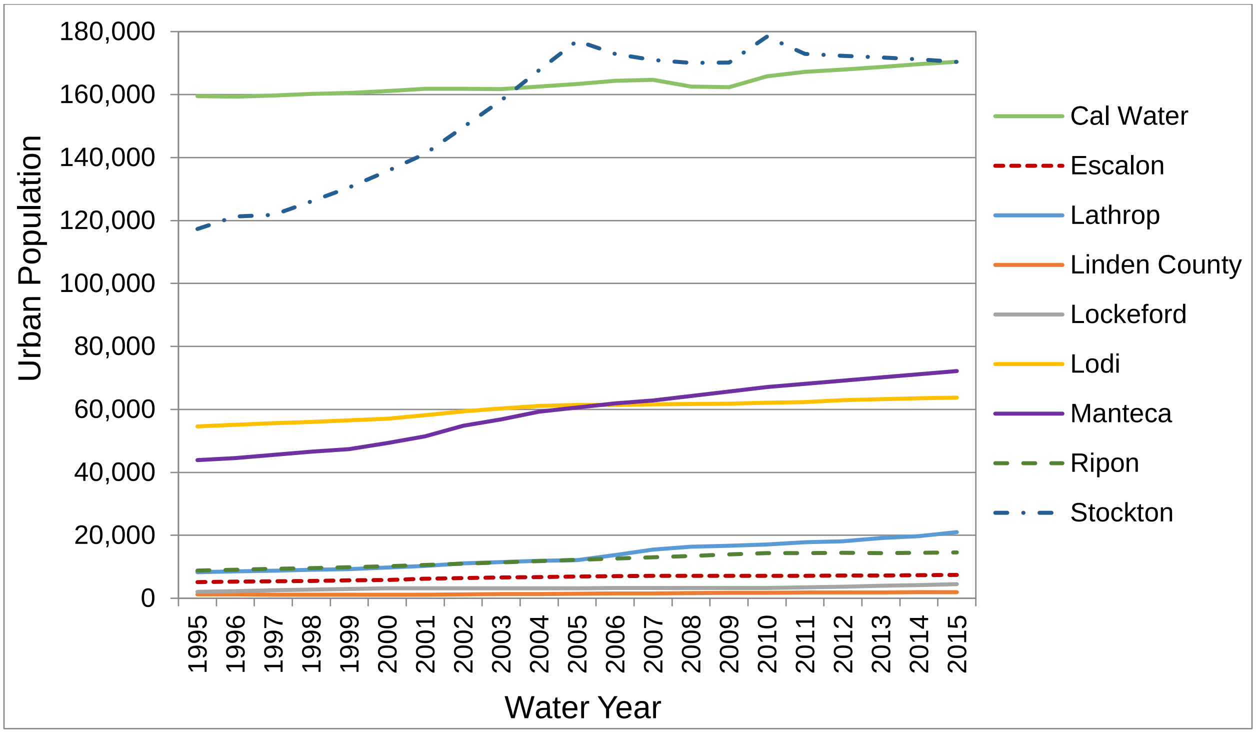


Figure 11: Urban Per Capita Water Use in Eastern San Joaquin Subbasin

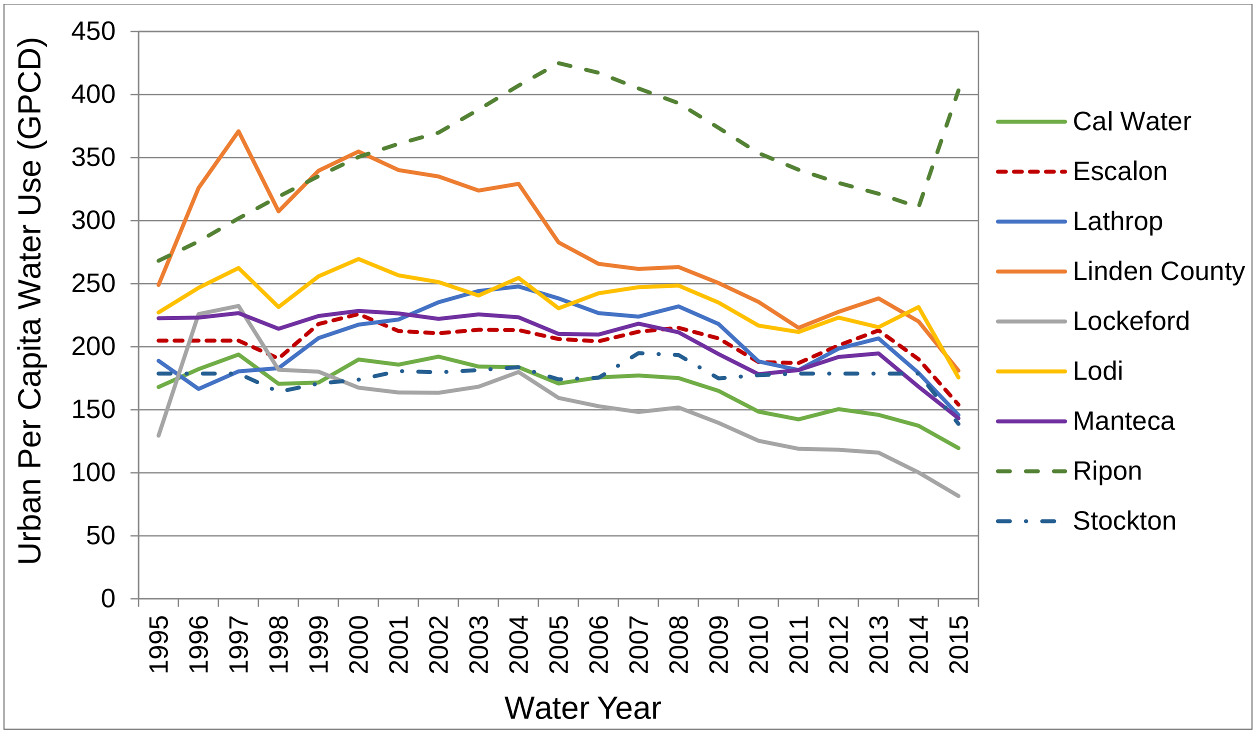


Figure 12a: Urban Demand- Eastern San Joaquin Subbasin

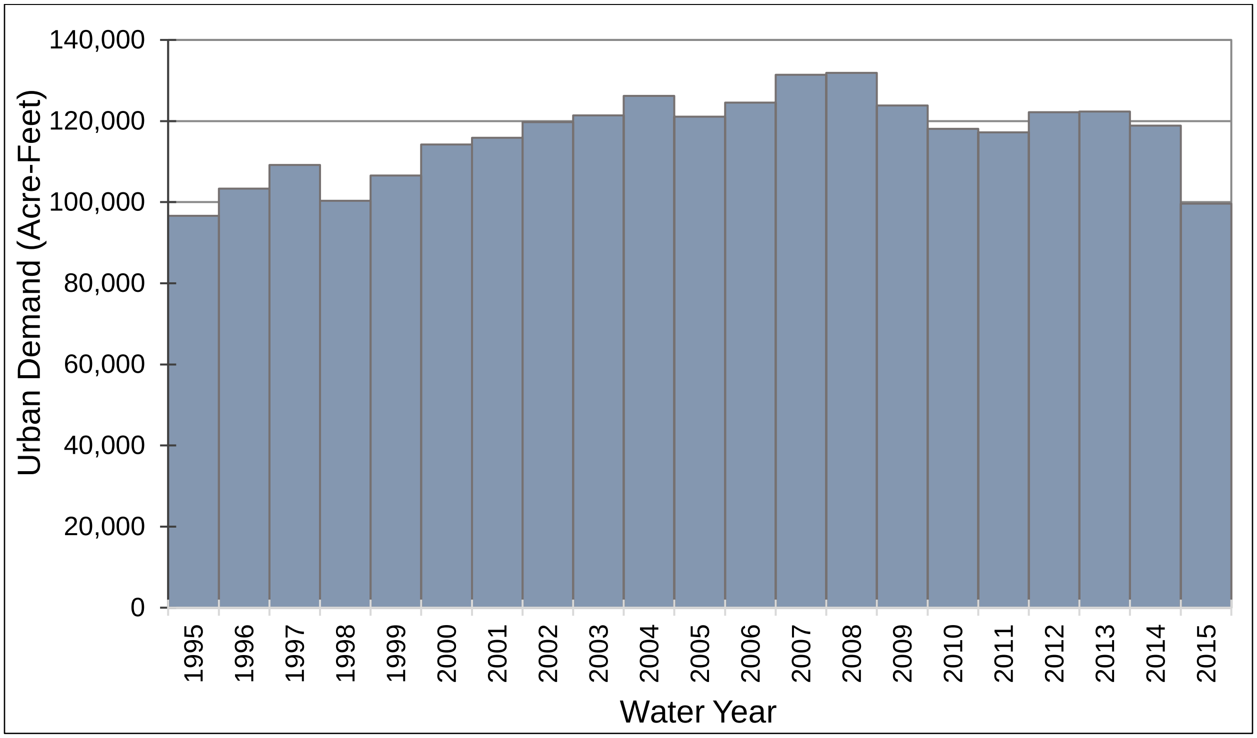


Figure 12b: Urban Demand- Subregion 3 (Lodi Subregion)

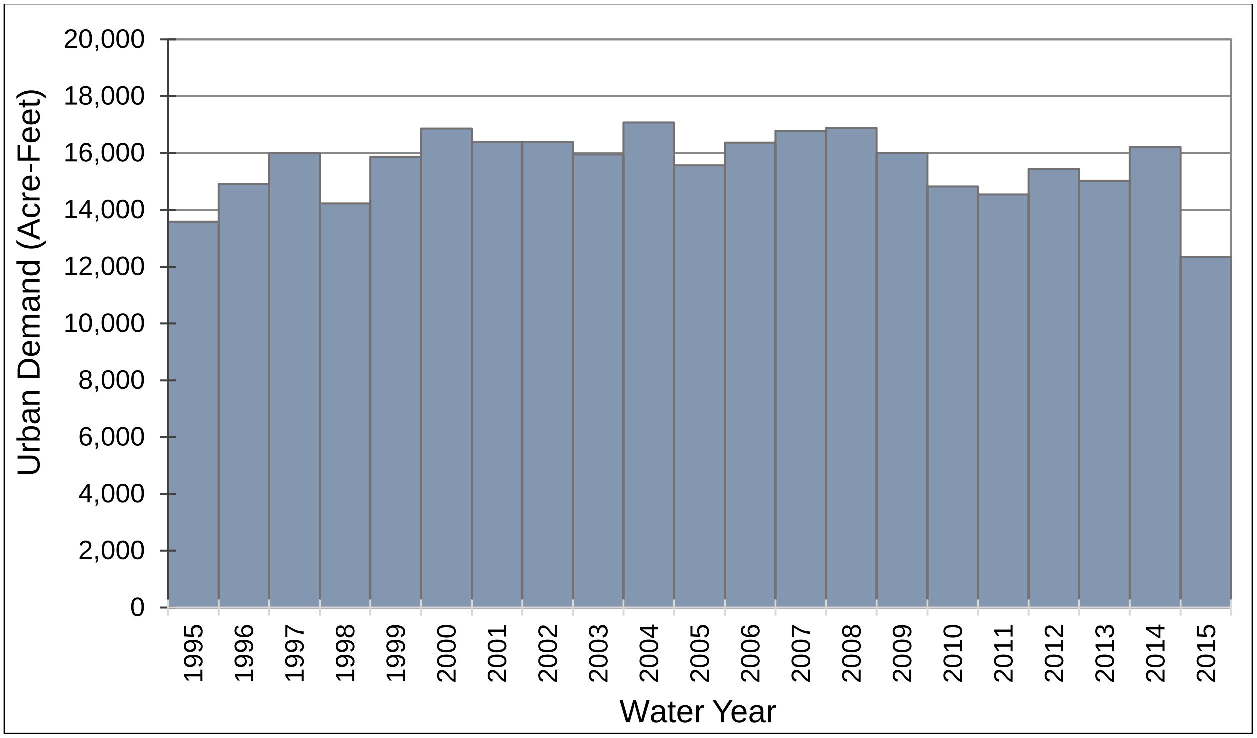


Figure 12c: Urban Demand- Subregion 6 (Stockton Subregion)

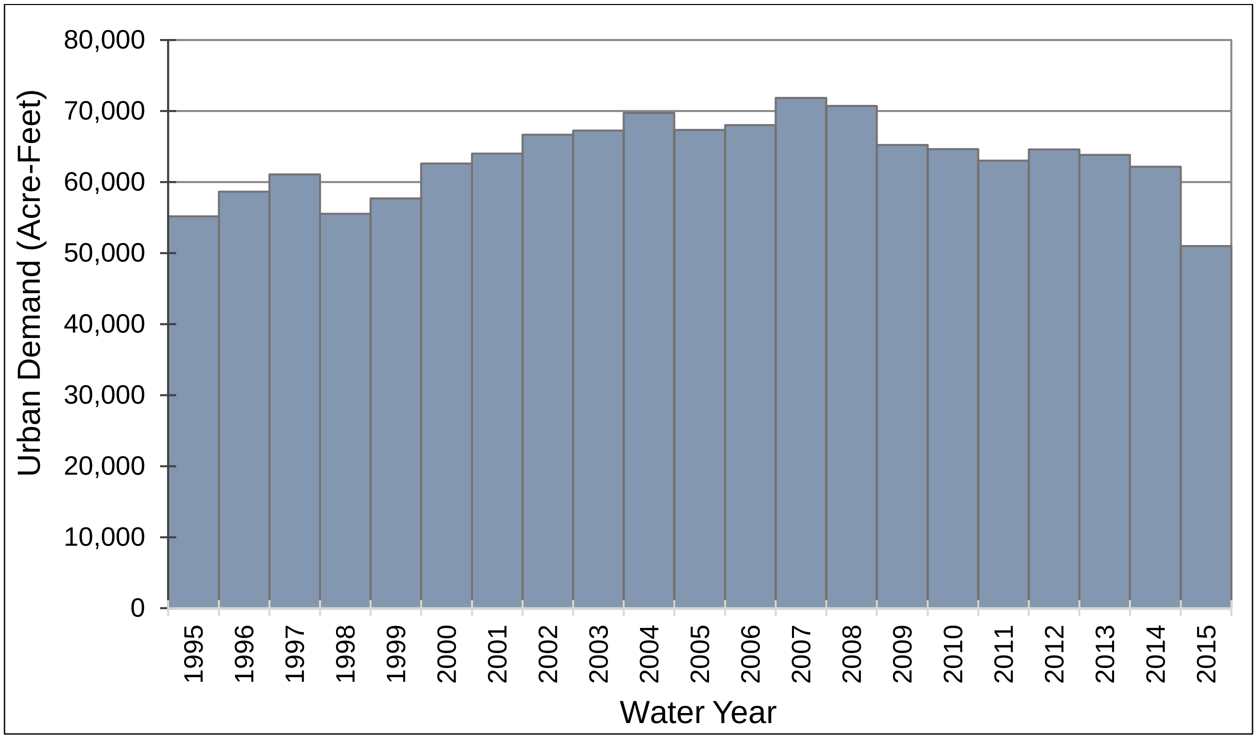


Figure 12d: Urban Demand- Subregion 9 (Lathrop Subregion)

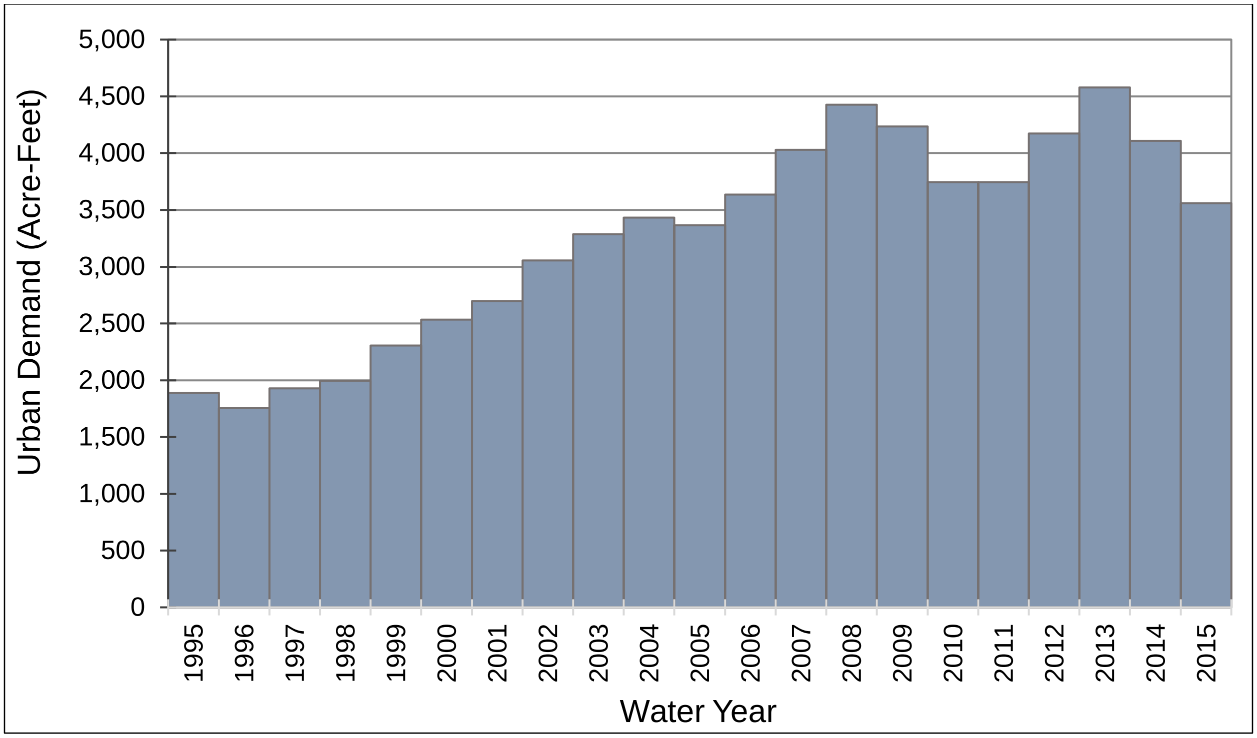


Figure 12e: Urban Demand- Subregion 10 (Manteca Subregion)

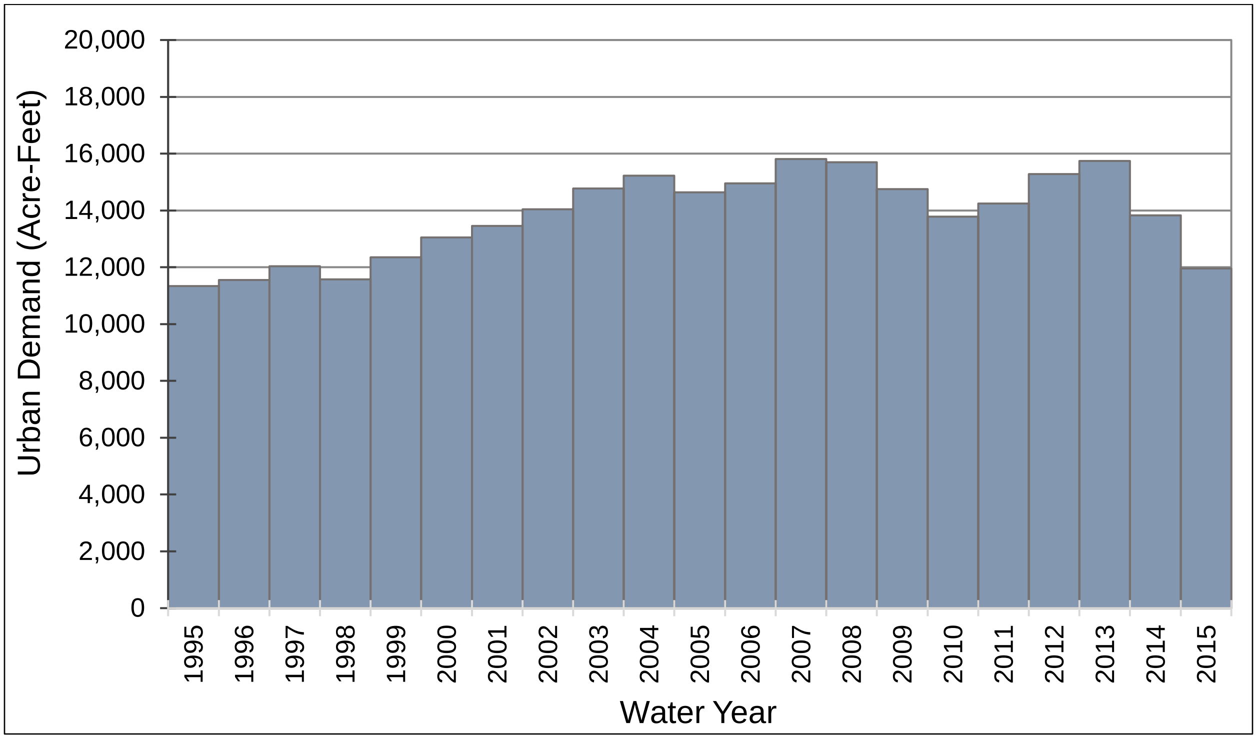


Figure 12f: Urban Demand- Subregion 12 (Escalon Subregion)

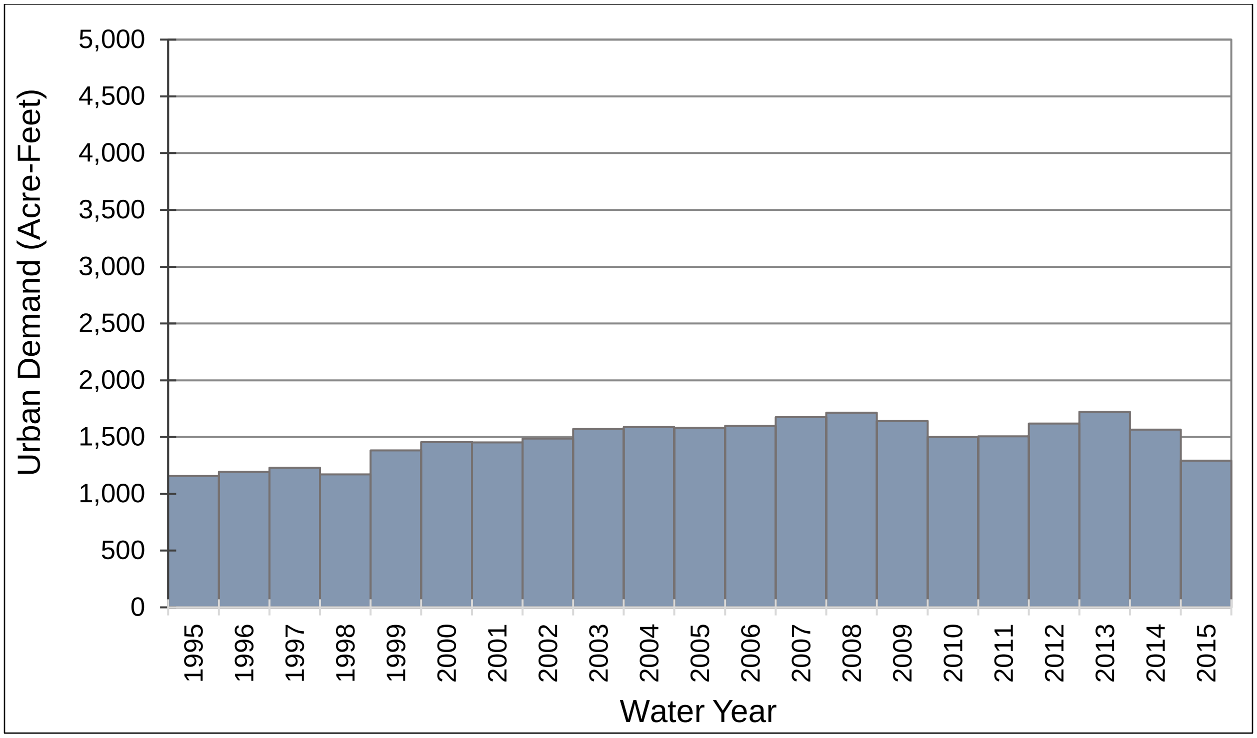


Figure 12g: Urban Demand- Subregion 16 (Ripon Subregion)

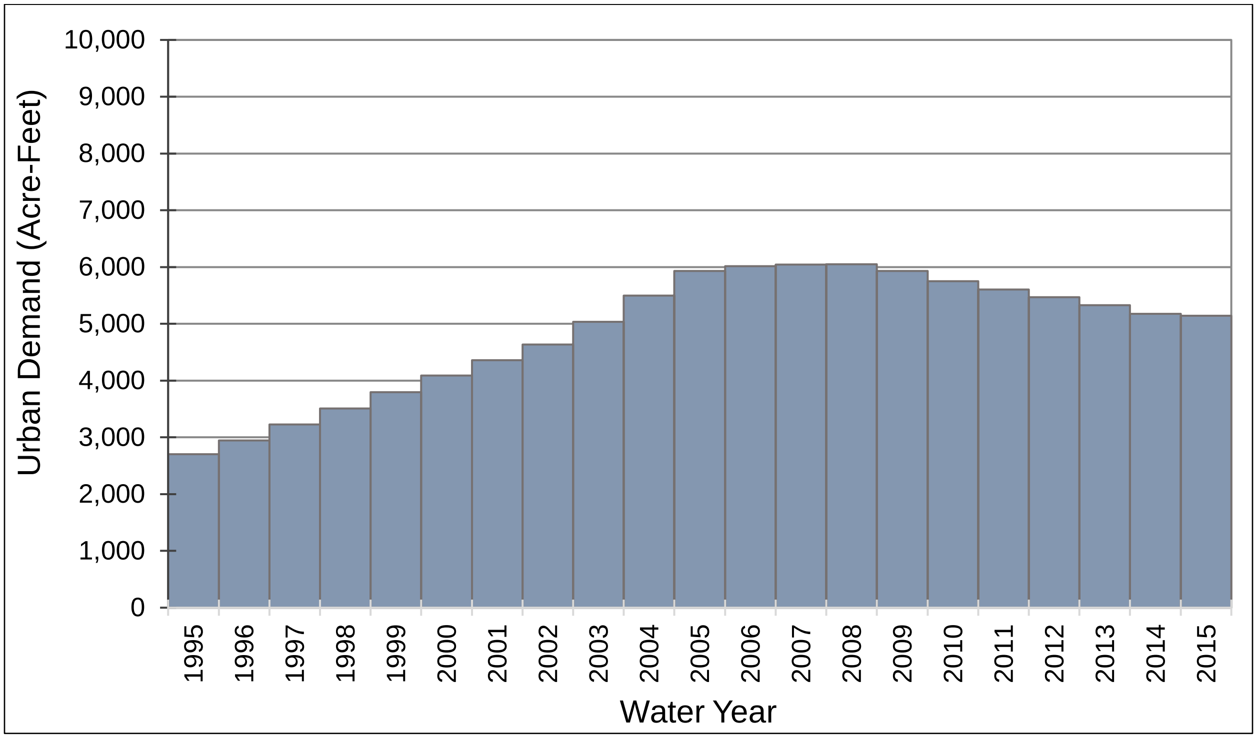


Figure 13: Annual Crop Evapotranspiration

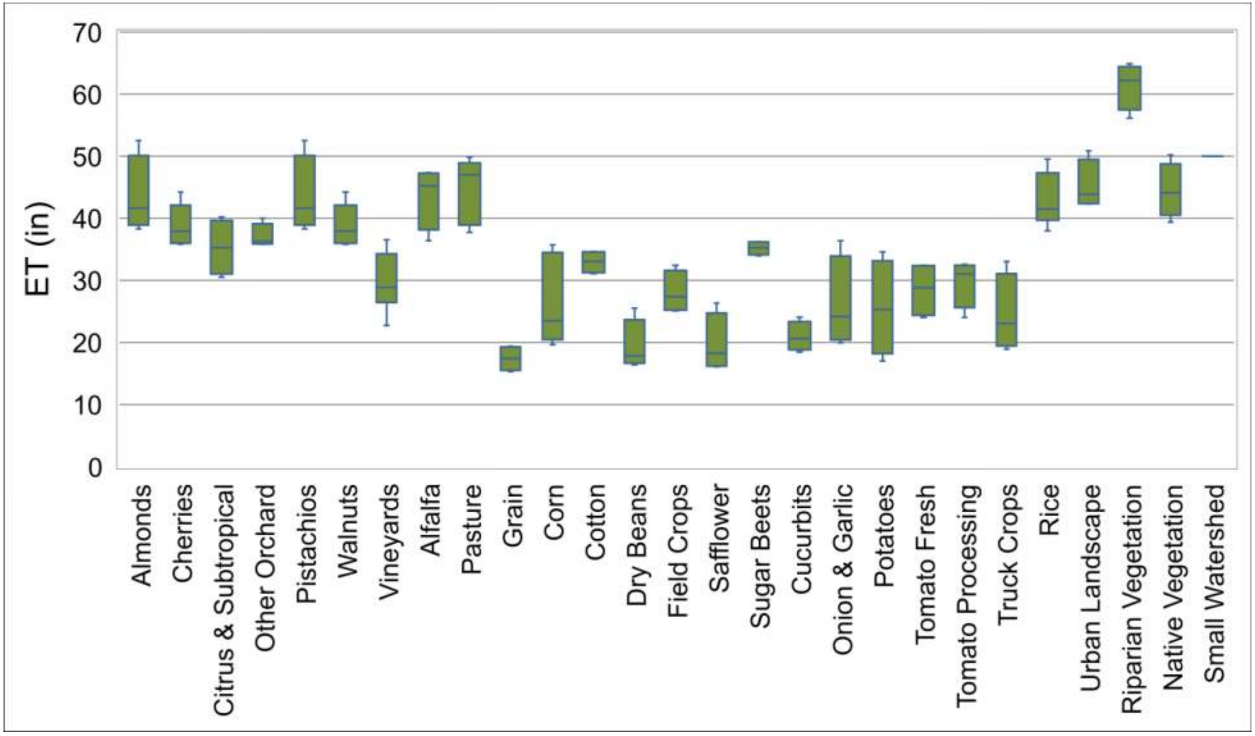


Figure 14: Annual Precipitation

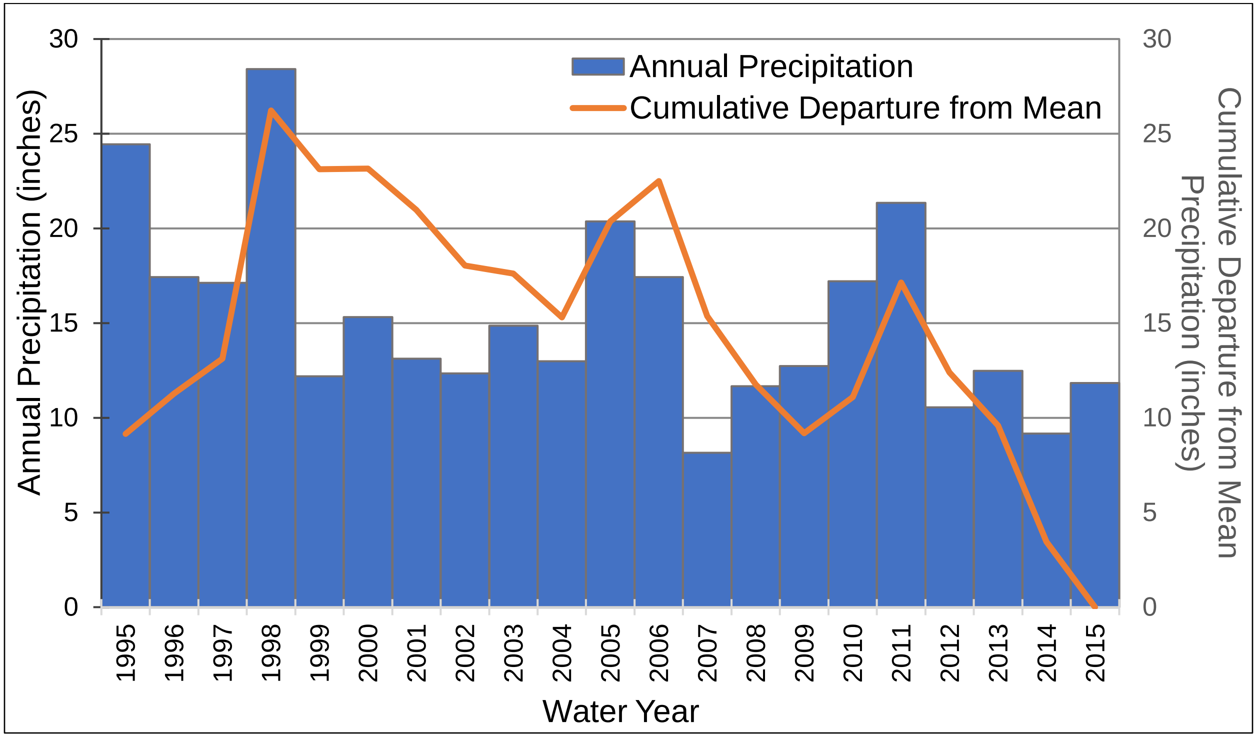


Figure 15a: Agricultural Demand- Eastern San Joaquin Subbasin

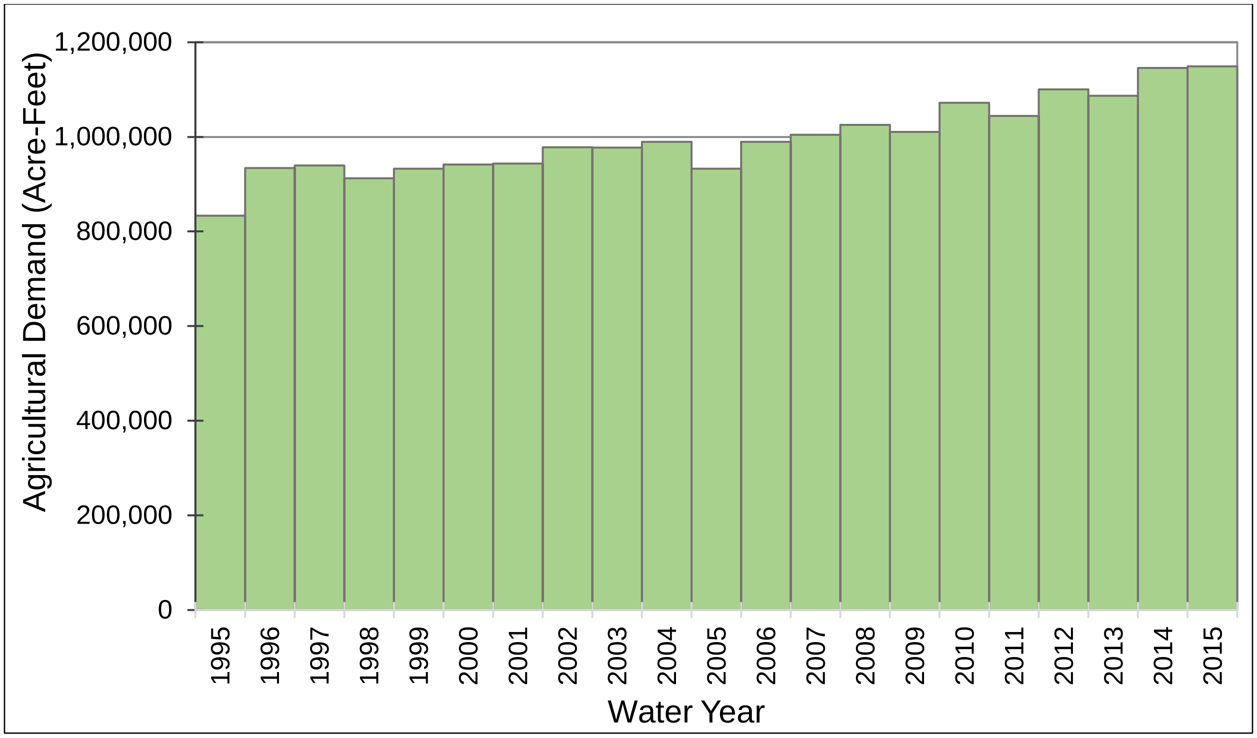


Figure 15b: Unit Agricultural Water Use and ETAW- Eastern San Joaquin Subbasin

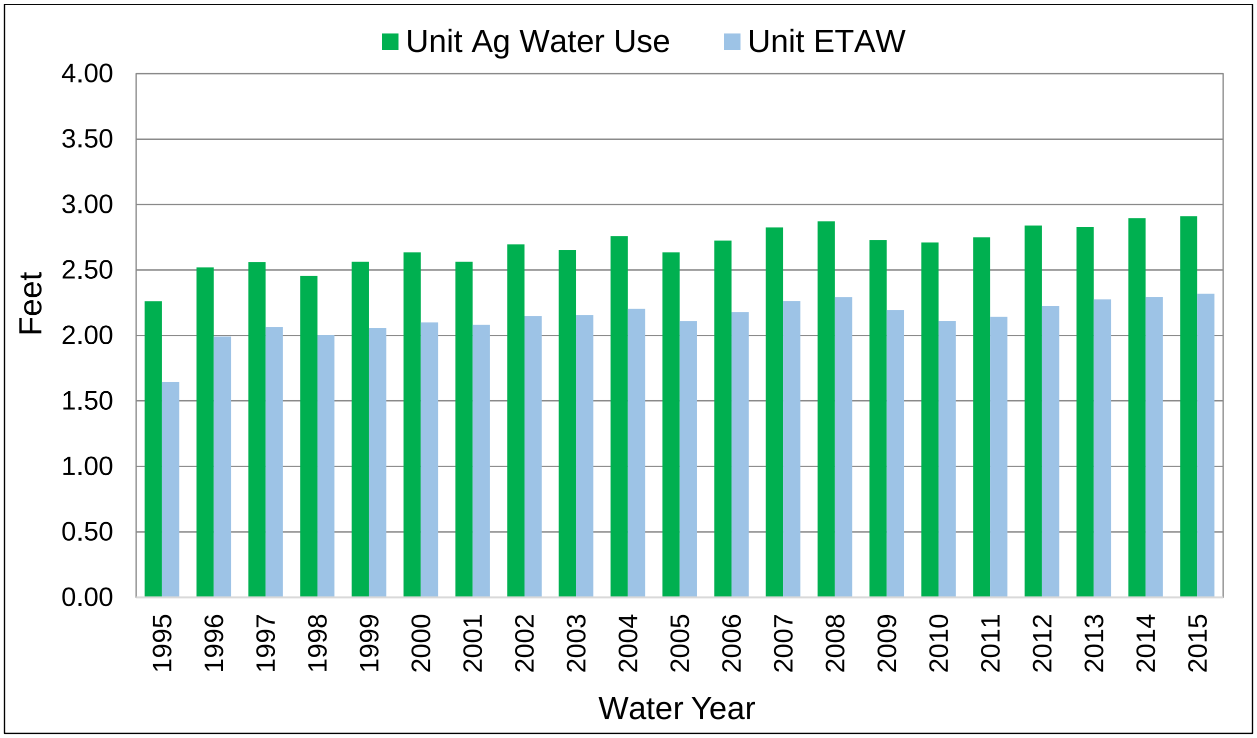


Figure 15c: Agricultural Demand- Subregion 2 (Woodbridge Subregion)

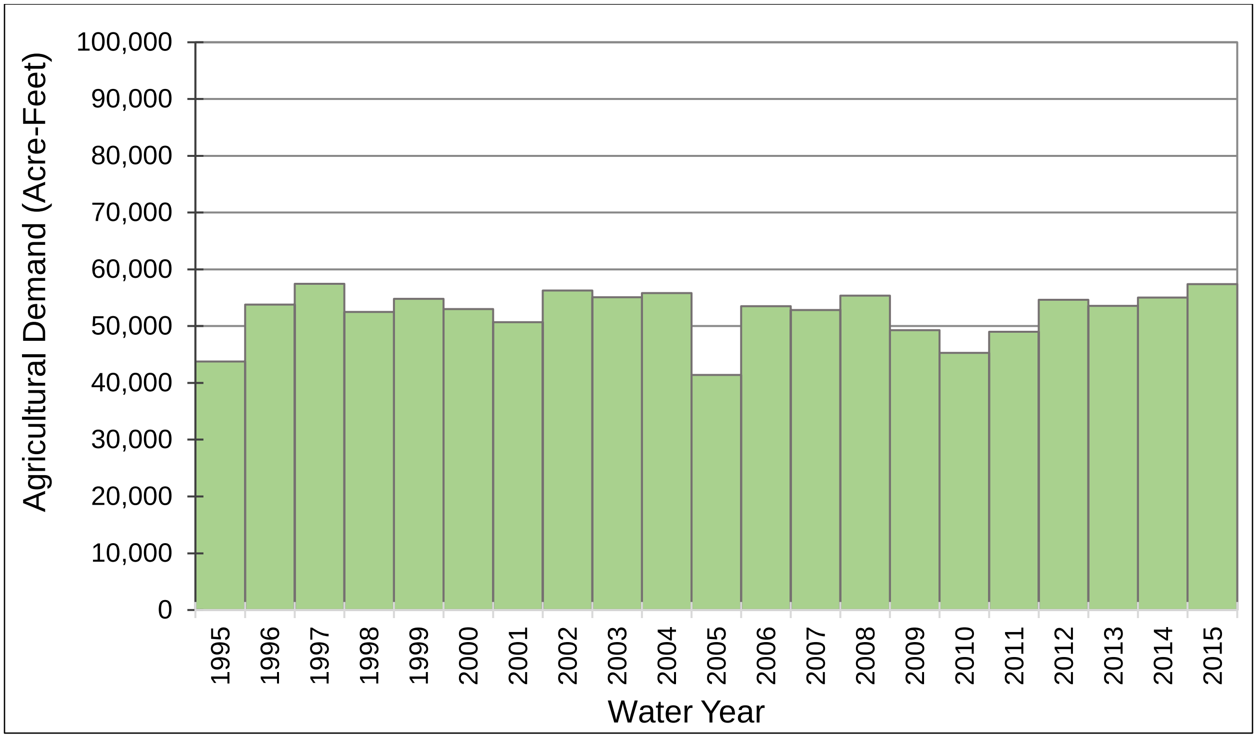


Figure 15d: Unit Agricultural Water Use and ETAW- Subregion 2 (Woodbridge Subregion)

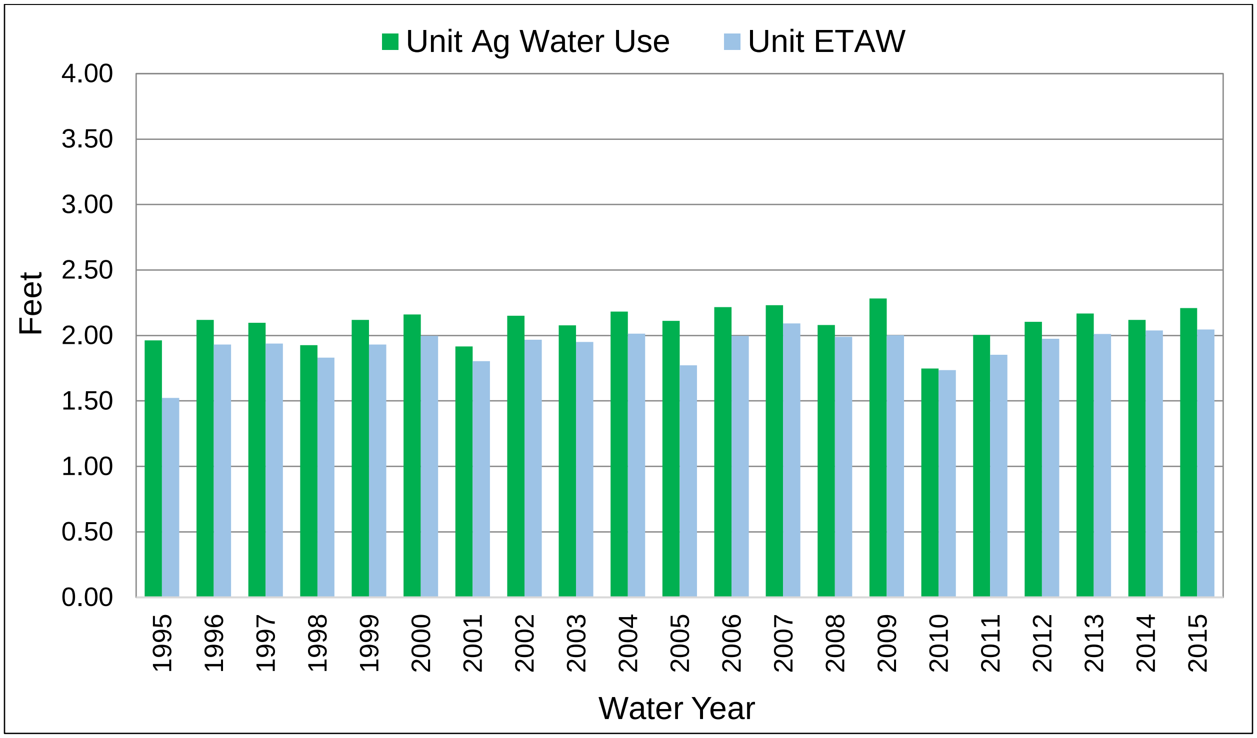


Figure 15e: Agricultural Demand- Subregion 4 (North San Joaquin Subregion)

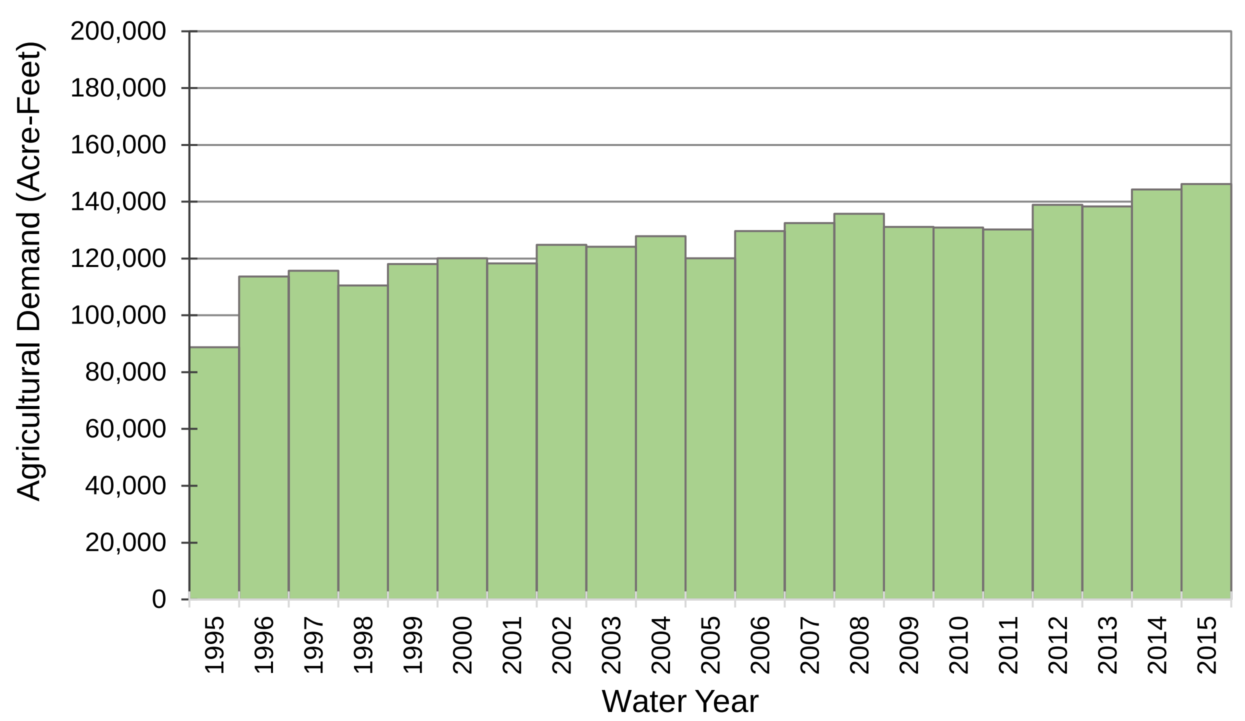


Figure 15f: Unit Agricultural Water Use and ETAW- Subregion 4 (North San Joaquin Subregion)

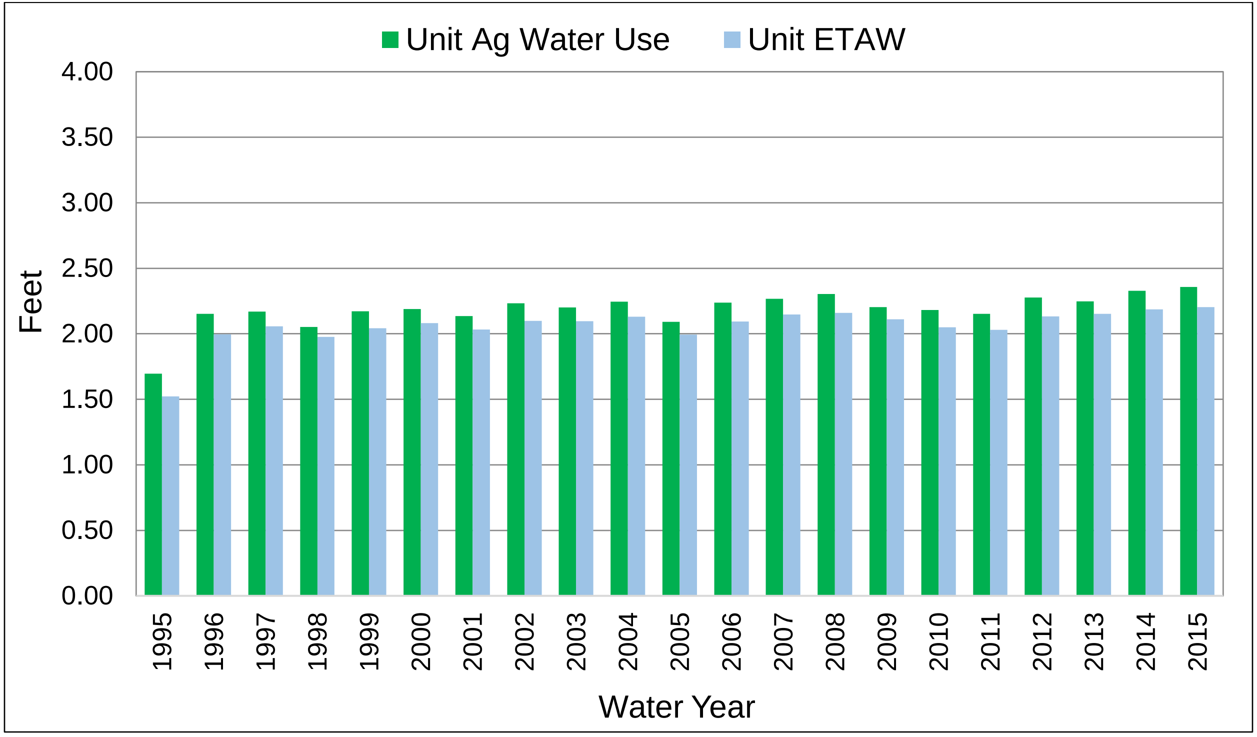


Figure 15g: Agricultural Demand- Subregion 7 (Stockton East Subregion)

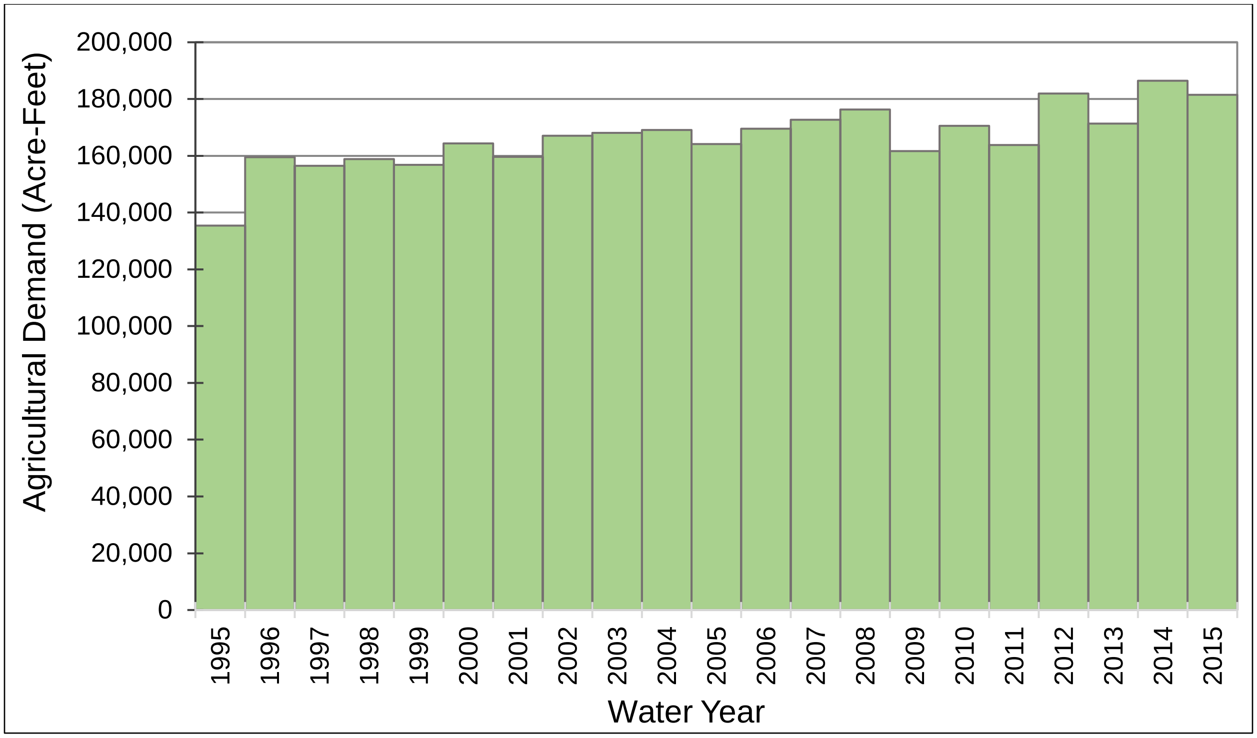


Figure 15h: Unit Agricultural Water Use and ETAW- Subregion 7 (Stockton East Subregion)

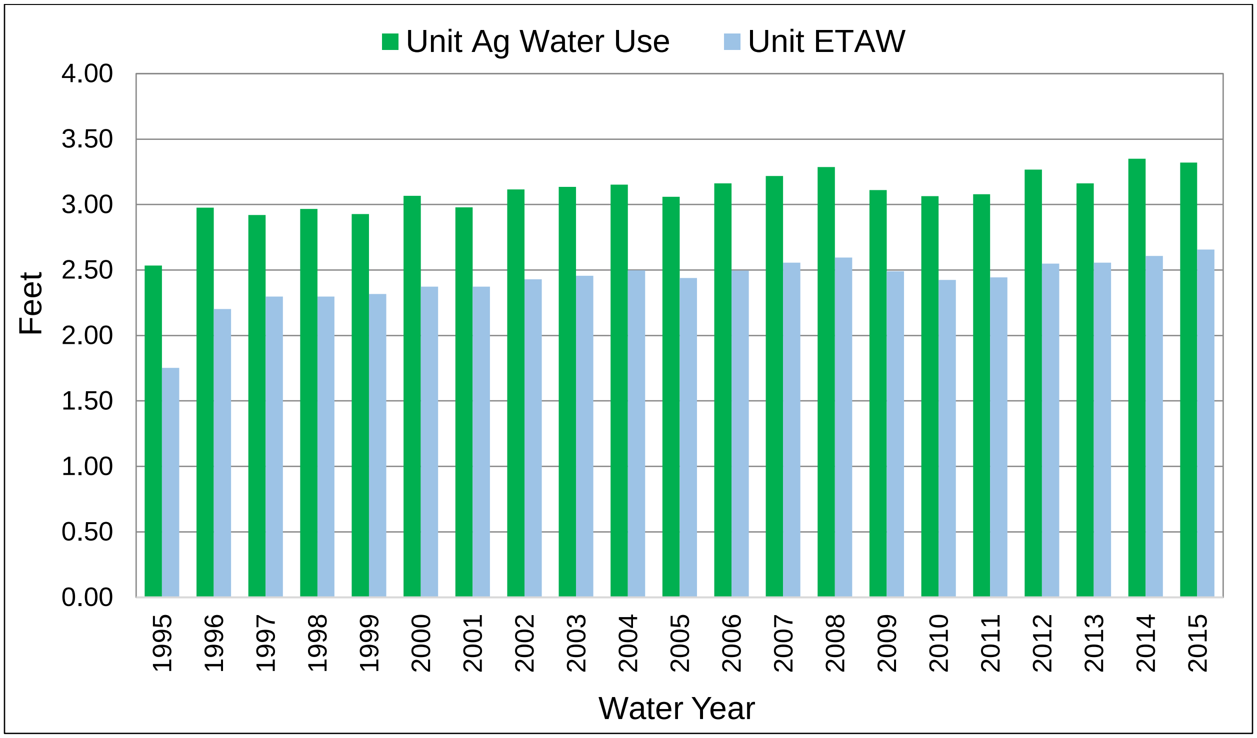


Figure 15i: Agricultural Demand- Subregion 11 (South San Joaquin East Subregion)

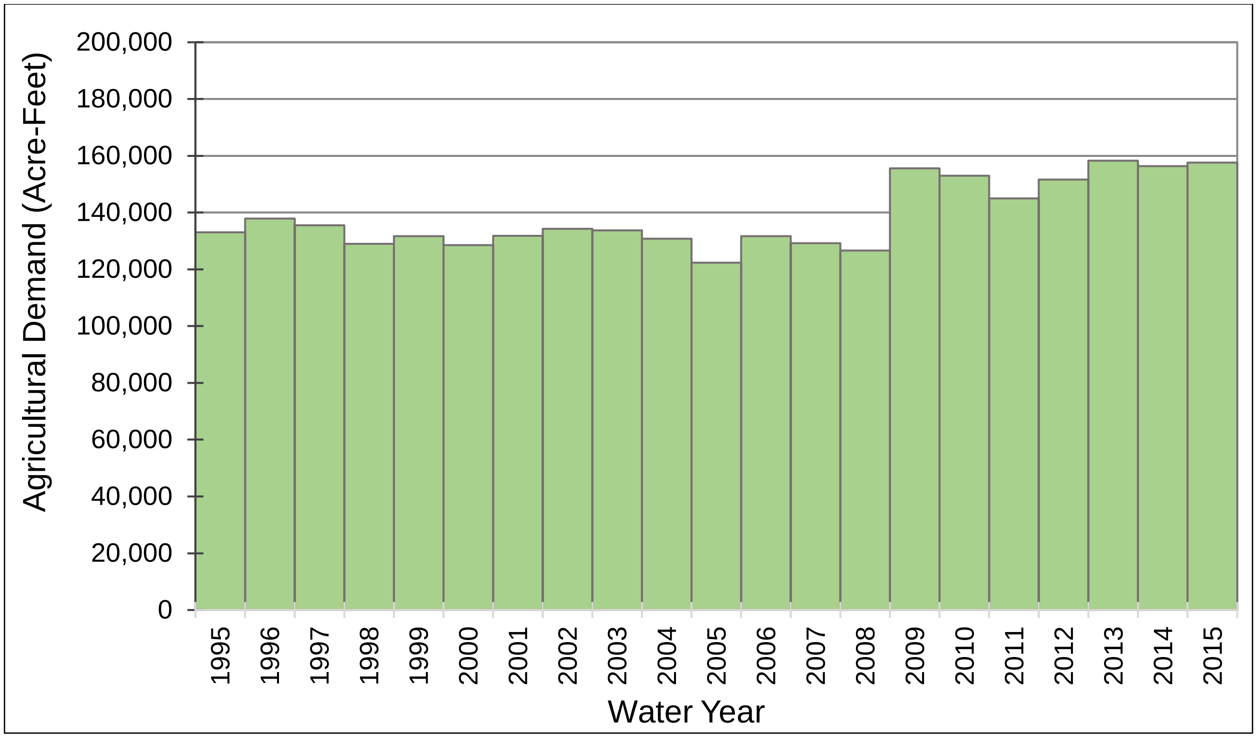


Figure 15j: Unit Agricultural Water Use and ETAW- Subregion 11 (South San Joaquin East Subregion)

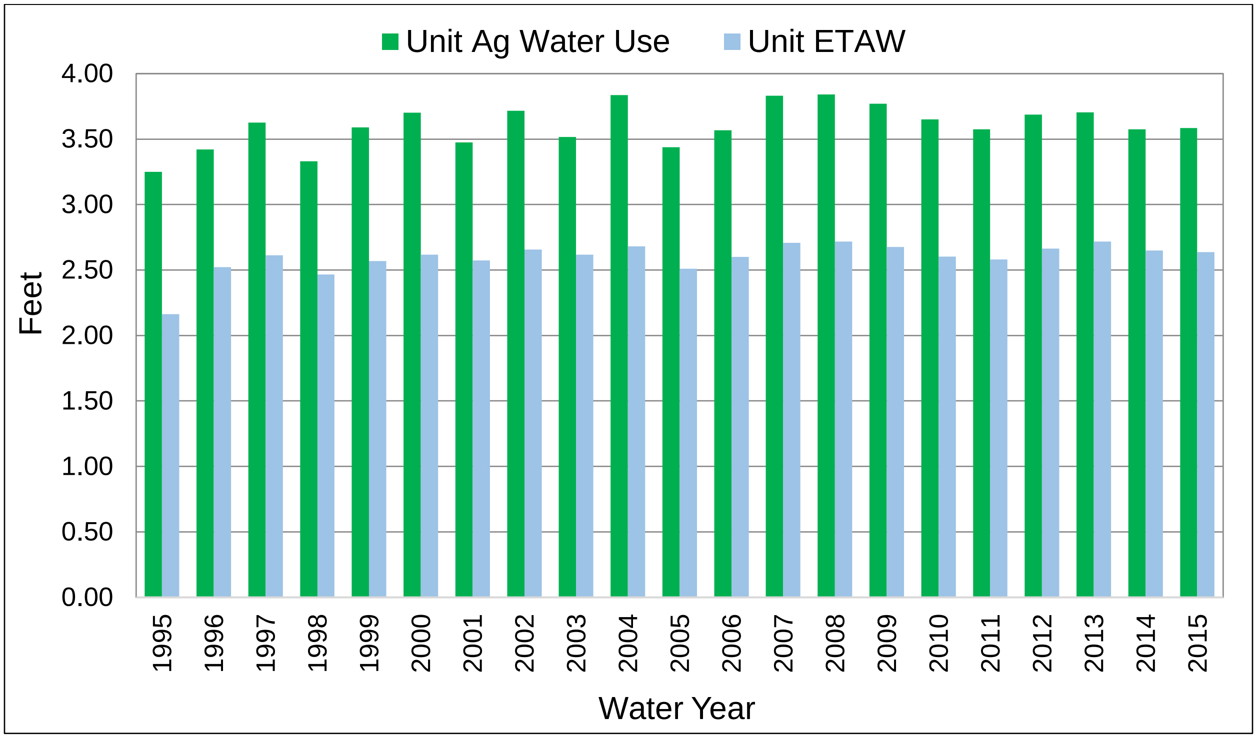


Figure 15k: Agricultural Demand- Subregion 13 (Oakdale West Subregion)

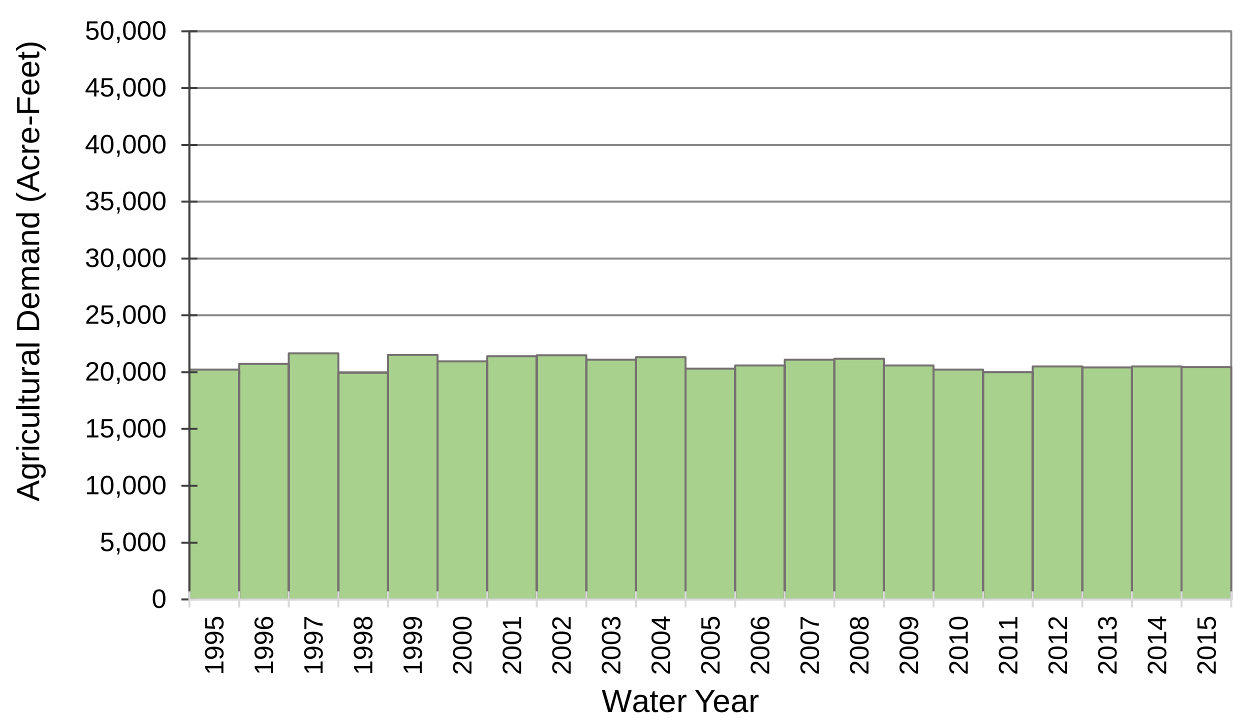


Figure 15l: Unit Agricultural Water Use and ETAW- Subregion 13 (Oakdale West Subregion)

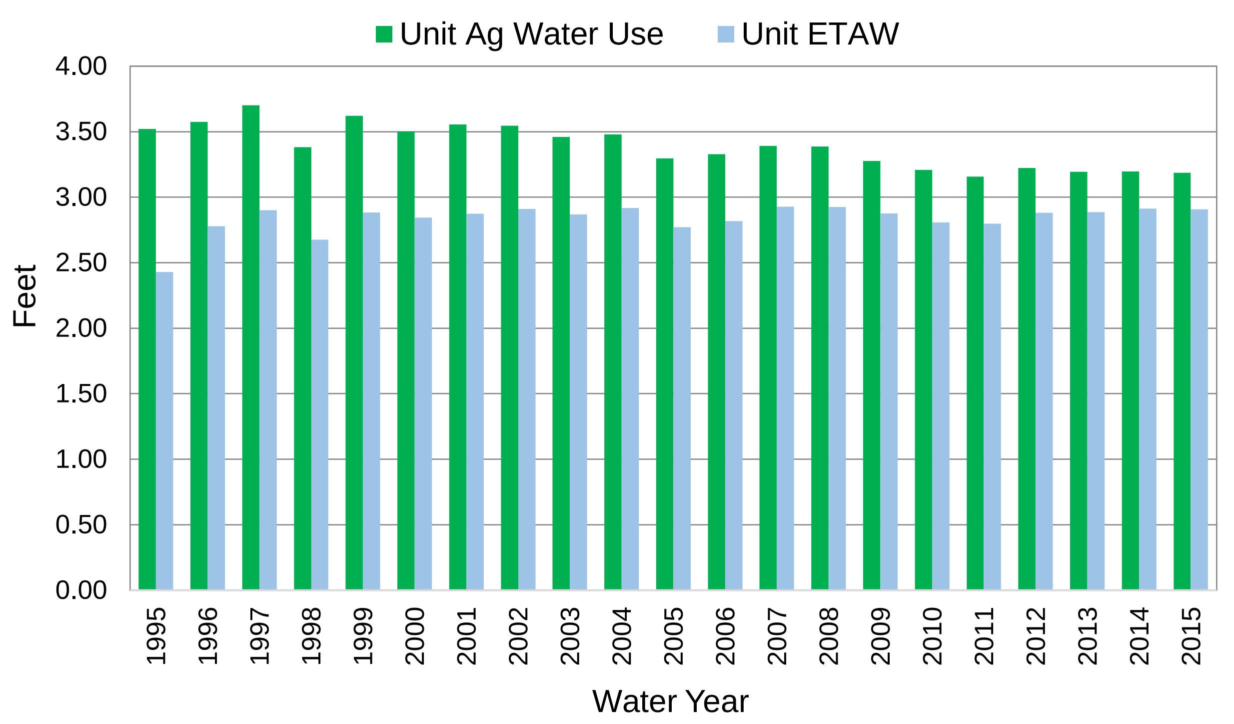


Figure 15m: Agricultural Demand- Subregion 18 (Oakdale East Subregion)

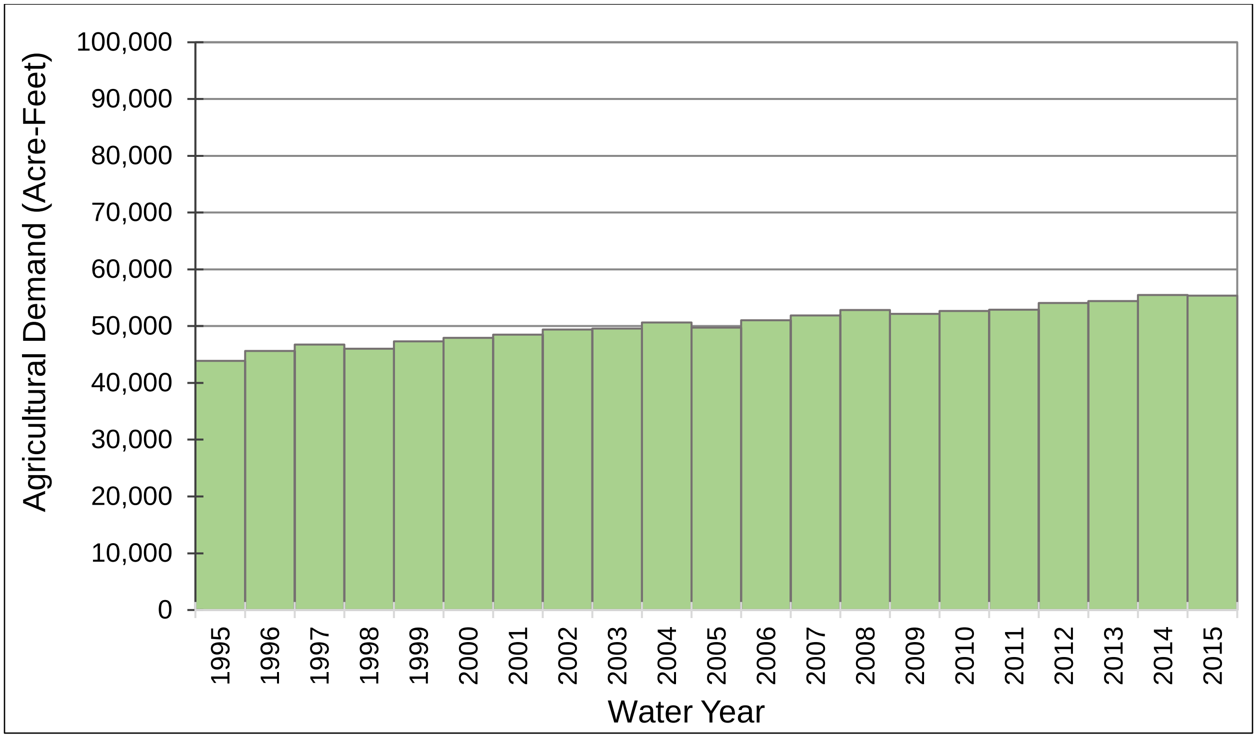
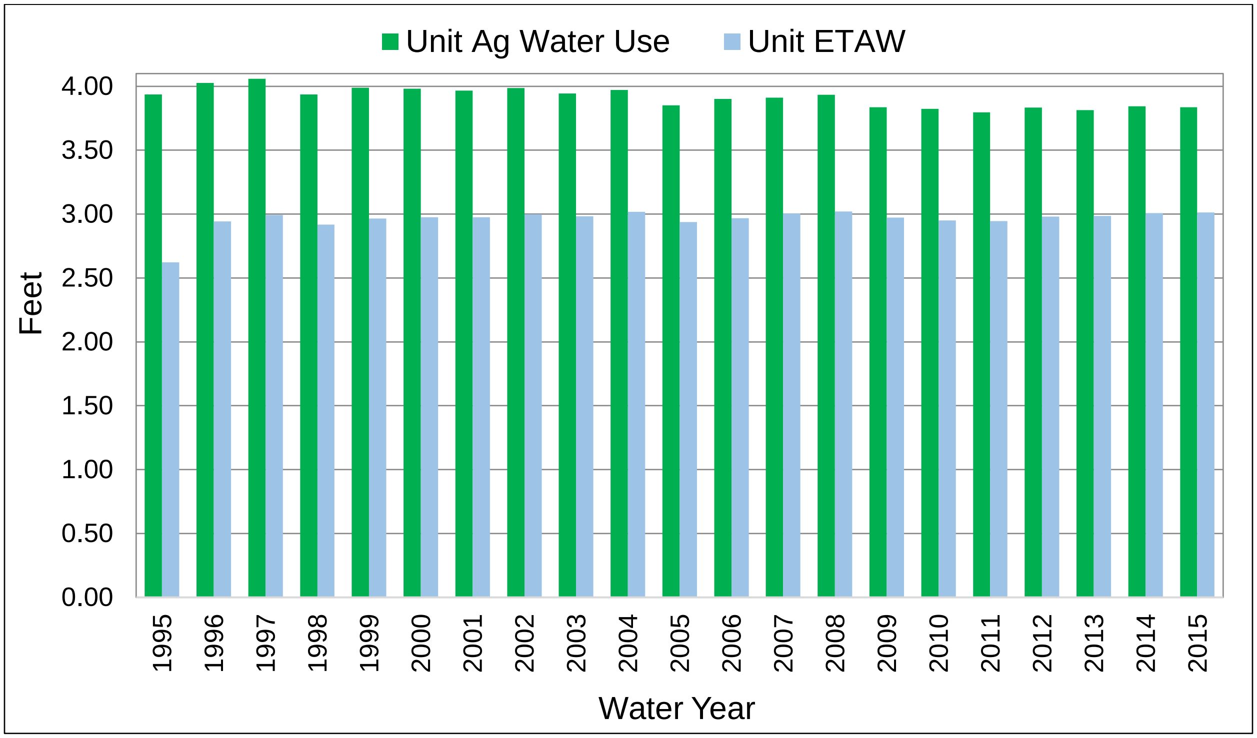


Figure 15n: Unit Agricultural Water Use and ETAW- Subregion 18 (Oakdale East Subregion)



APPENDIX C: ESJWRM CALIBRATION WELLS

Figure C-1: ESJWRM Groundwater Level Calibration Wells

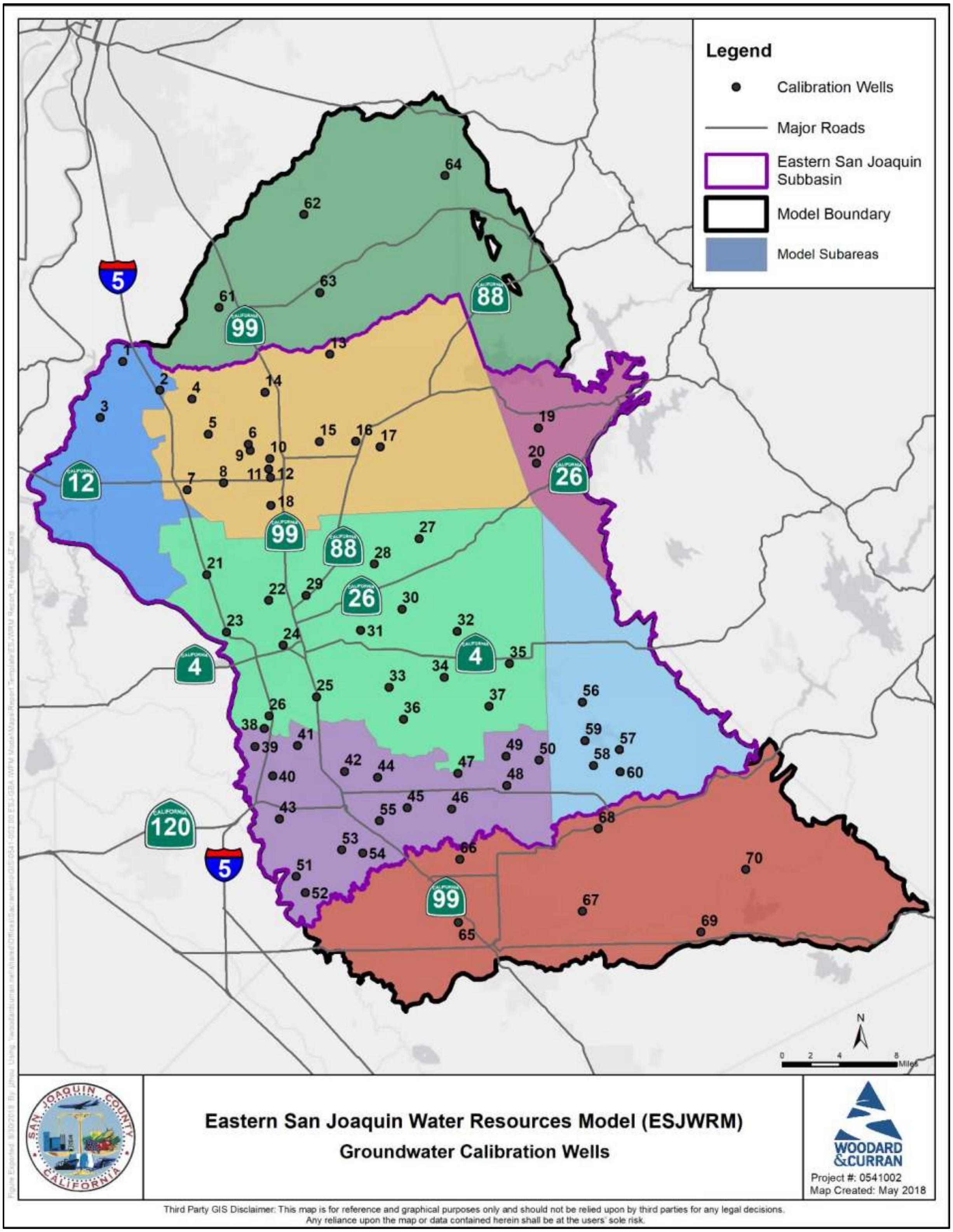


Table C-1: ESJWRM Groundwater Level Calibration Wells

Hydrograph ID	ID by Model Subregion	Well Name	Well Source	Agency*	Well Type	Depth	Screening Intervals
1	101	05N05E32M001	Voluntary	SJCFCWCD	Stockwatering	145	Unknown
2	102	04N05E10K001	CASGEM	SJCFCWCD	Residential	115	90/115
3	103	04N04E24F001M	Voluntary	DWR	Observation	20	Unknown
4	201	04N05E13H001	CASGEM	SJCFCWCD	Irrigation	190	50/190
5	202	04N06E29N002	Voluntary	SJCFCWCD	Irrigation	475	204/475
6	203	04N06E34J002	Voluntary	SJCFCWCD	Irrigation	466	94/167, 172/466
7	204	03N05E13L001	Voluntary	SJCFCWCD	Irrigation	65	Unknown
8	205	03N06E17A004	Voluntary	SJCFCWCD	Unknown	128	60/128
9	301	Lodi Well 7	Local Agency	City of Lodi	Production	422	142/422
10	302	Lodi Well 2	Local Agency	City of Lodi	Production	315	109/310
11	303	Lodi G-25B	Local Agency	City of Lodi	Observation	150	140/150
12	304	Lodi MW-19	CASGEM	SJCFCWCD	Observation	73	58/73
13	401	05N07E34G001M	Voluntary	DWR	Irrigation	590	Unknown
14	402	04N06E12N002	CASGEM	SJCFCWCD	Irrigation	320	104/320
15	403	04N07E33H001	Voluntary	SJCFCWCD	Irrigation	104	Unknown
16	404	04N07E36L001	Voluntary	DWR	Irrigation	565	Unknown
17	405	04N08E32N001	Voluntary	SJCFCWCD	Irrigation	Unknown	Unknown
18	406	03N06E24M003M	Voluntary	DWR	Irrigation	237	156/237
19	501	CCWD 010	CASGEM	CCWD	Observation	390	Unknown
20	502	CCWD 006	CASGEM	CCWD	Observation	230	Unknown
21	601	02N06E18K001M	Voluntary	DWR	Unknown	650	Unknown
22	602	02N06E26H001	Voluntary	SJCFCWCD	Irrigation	Unknown	Unknown
23	603	01N06E05H001	Voluntary	DWR	Irrigation	315	235/277
24	604	01N06E12G001	Voluntary	DWR	Irrigation	230	210/230
25	605	01N07E32A001	Voluntary	DWR	Irrigation	232	178/232
26	606	01S06E02G002	Voluntary	DWR	Irrigation	135	101/135
27	701	02N08E03G002	Voluntary	SJCFCWCD	Residential	125	Unknown
28	702	02N08E18C001	Voluntary	SJCFCWCD	Irrigation	544	Unknown
29	703	02N07E29B001	CASGEM	SJCFCWCD	Irrigation	202	130/202
30	704	02N08E33E001	Voluntary	SJCFCWCD	Irrigation	168	Unknown
31	705	01N07E01M002	Voluntary	SJCFCWCD	Irrigation	364	104/108
32	801	01N09E06N001	Voluntary	SJCFCWCD	Irrigation	300	92/300
33	802	01N08E29M002	Voluntary	SJCFCWCD	Irrigation	460	Unknown
34	803	01N08E26A002	Voluntary	SJCFCWCD	Irrigation	216	176/216
35	804	01N09E22G002	Voluntary	SJCFCWCD	Irrigation	340	Unknown
36	805	01S08E05R001	Voluntary	SJCFCWCD	Unknown	125	Unknown

Hydrograph ID	ID by Model Subregion	Well Name	Well Source	Agency*	Well Type	Depth	Screening Intervals
37	806	01S09E05H002	CASGEM	SJCFCWCD	Irrigation	256	148/256
38	901	01S06E11E001M	Voluntary	DWR	Irrigation	185	Unknown
39	902	01S06E15F001M	Voluntary	DWR	Residential	188	160/184
40	903	01S06E26K001M	Voluntary	DWR	Irrigation	248	191/195
41	1001	01S07E18L001M	Voluntary	DWR	Residential	248	144/154
42	1002	01S07E27K001	Voluntary	SJCFCWCD	Irrigation	300	120/300
43	1003	02S06E11J001	Voluntary	DWR	Irrigation	165	Unknown
44	1101	01S07E25R001M	Voluntary	DWR	Irrigation	130	Unknown
45	1102	02S08E08A001	CASGEM	SJCFCWCD	Irrigation	180	50/180
46	1103	02S08E12D001	Voluntary	DWR	Residential	82	72/82
47	1104	01S08E25Q001	Voluntary	SJCFCWCD	Irrigation	450	Unknown
48	1105	01S09E33J002	Voluntary	DWR	Residential	95	88/95
49	1301	01S09E21J002	CASGEM	SJCFCWCD	Irrigation	223	195/223
50	1302	01S09E24R001	Voluntary	SJCFCWCD	Irrigation	264	176/264
51	1401	02S07E31N001	Voluntary	SJCFCWCD	Irrigation	226	130/226
52	1402	03S07E06Q001	Voluntary	DWR	Stockwatering	71	Unknown
53	1501	02S07E22N002	Voluntary	DWR	Irrigation	162	52/162
54	1502	02S07E26B001	Voluntary	SJCFCWCD	Irrigation	386	56/386
55	1601	02S07E12R001	Voluntary	SJCFCWCD	Residential	310	Unknown
56	1701	01S10E04C001	Voluntary	DWR	Unknown	Unknown	Unknown
57	1702	01S10E23H001M	Voluntary	DWR	Irrigation	300	Unknown
58	1703	01S10E28J001	Voluntary	DWR	Unknown	Unknown	Unknown
59	1801	1S10E16Q1-18	Voluntary	DWR	Irrigation	299	Unknown
60	1802	01S10E26J001M	CASGEM	Stanislaus County	Unknown	Unknown	Unknown
61	1901	05N06E08R001M	Voluntary	DWR	Irrigation	Unknown	Unknown
62	1902	06N07E08R001M	Voluntary	DWR	Residential	332	Unknown
63	1903	05N07E10D001M	Voluntary	DWR	Residential	260	180/260
64	1904	07N08E36B001M	CASGEM	SSCAWA	Observation	15	Unknown
65	2001	03S08E23H001M	CASGEM	MID	Irrigation	467	Unknown
66	2002	American 208	CASGEM	MID	Irrigation	320	Unknown
67	2003	03S10E17K001M	CASGEM	MID	Irrigation	476	116/400
68	2004	Birnbaum OID-03	CASGEM	STRGBA GSA	Irrigation	293	55/110, 147/154, 170/175, 185/200, 238/250, 265/270, 285/293

Hydrograph ID	ID by Model Subregion	Well Name	Well Source	Agency*	Well Type	Depth	Screening Intervals
69	2005	03S11E27G003M	CASGEM	STRGBA GSA	Irrigation	248	Unknown
70	2006	Paulsell 2 OID-12	CASGEM	STRGBA GSA	Irrigation	815	132/159, 160/815

* CCWD = Calaveras County Water District
DWR = Department of Water Resources
MID = Modesto Irrigation District
SJCFCWCD = San Joaquin County Flood Control and Water Conservation District
SSCAWA = Southeast Sacramento County Agricultural Water Authority
STRGBA GSA = Stanislaus & Tuolumne Rivers Groundwater Basin Association GSA

Figure C-2: ESJWRM Groundwater Level Hydrograph – Calibration Well #1

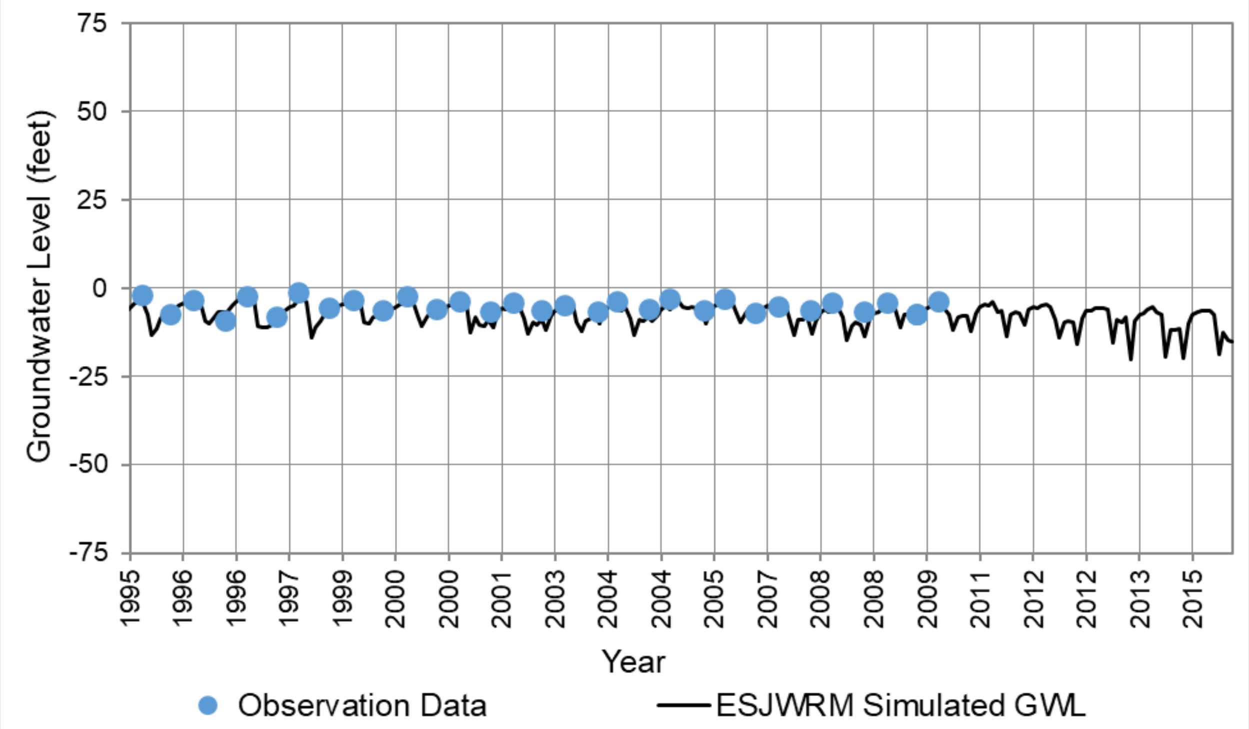


Figure C-3: ESJWRM Groundwater Level Hydrograph – Calibration Well #2

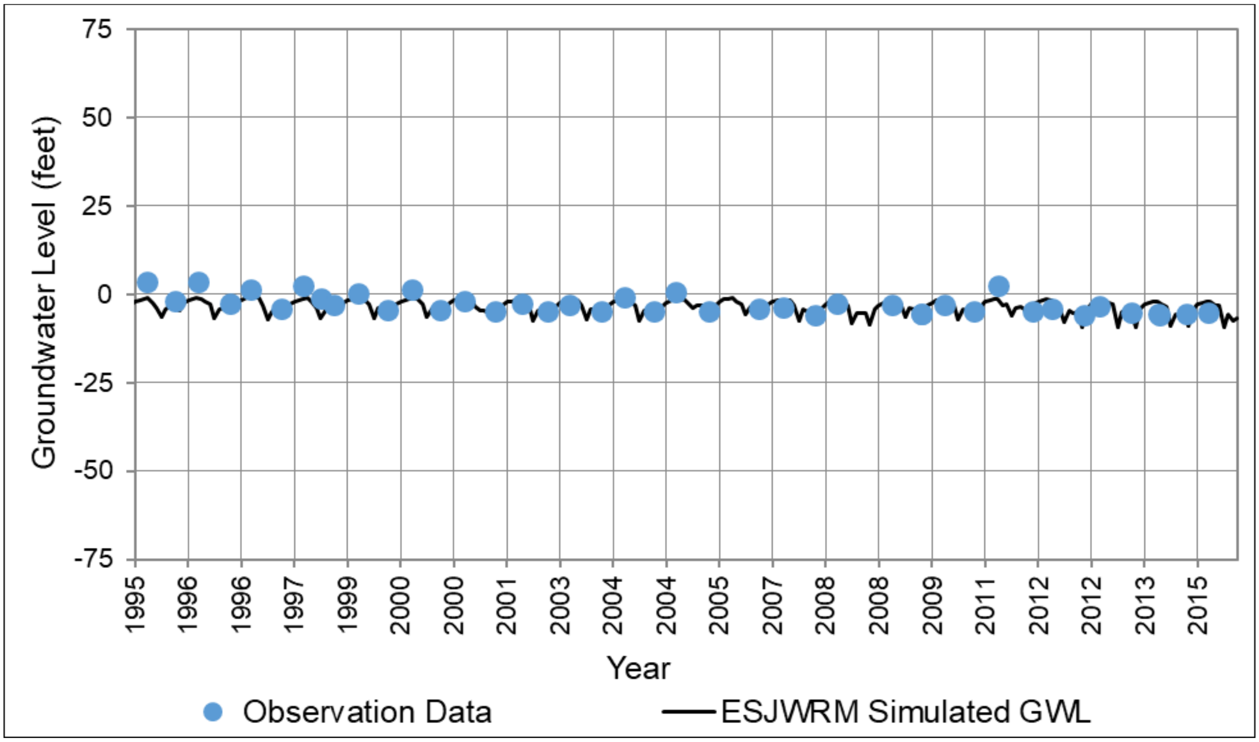


Figure C-4: ESJWRM Groundwater Level Hydrograph – Calibration Well #3

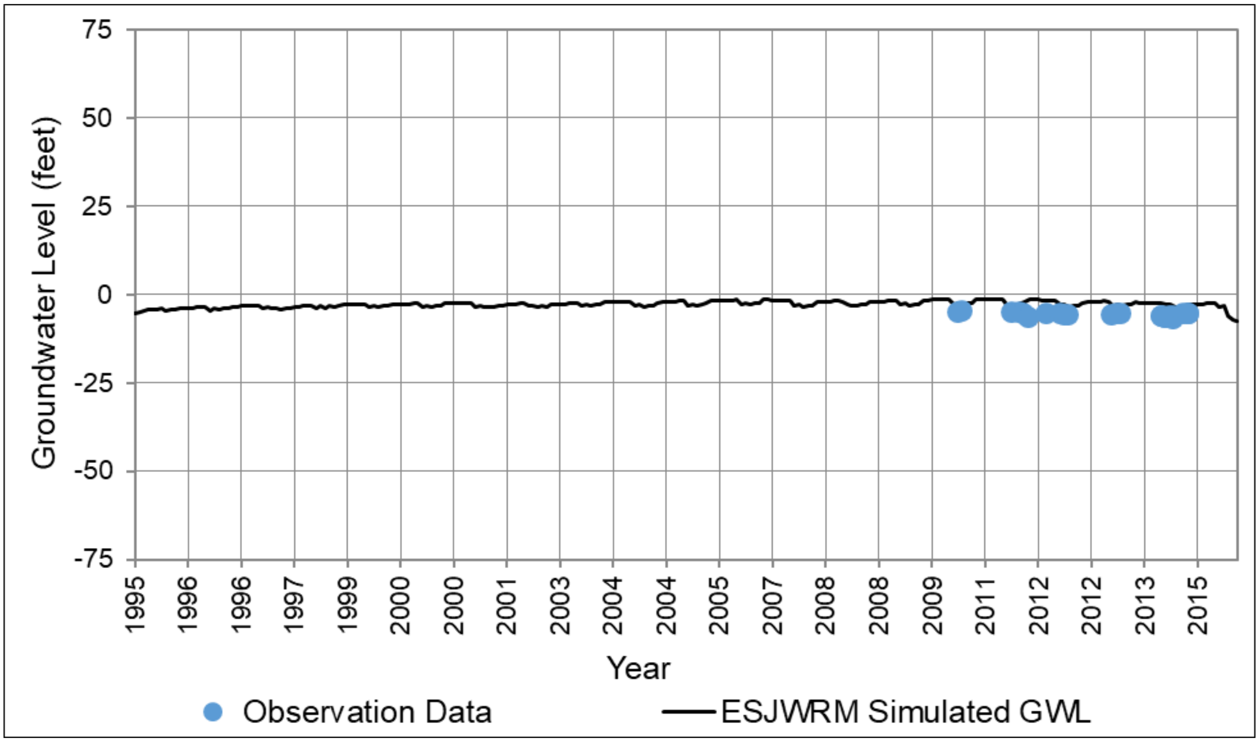


Figure C-5: ESJWRM Groundwater Level Hydrograph – Calibration Well #4

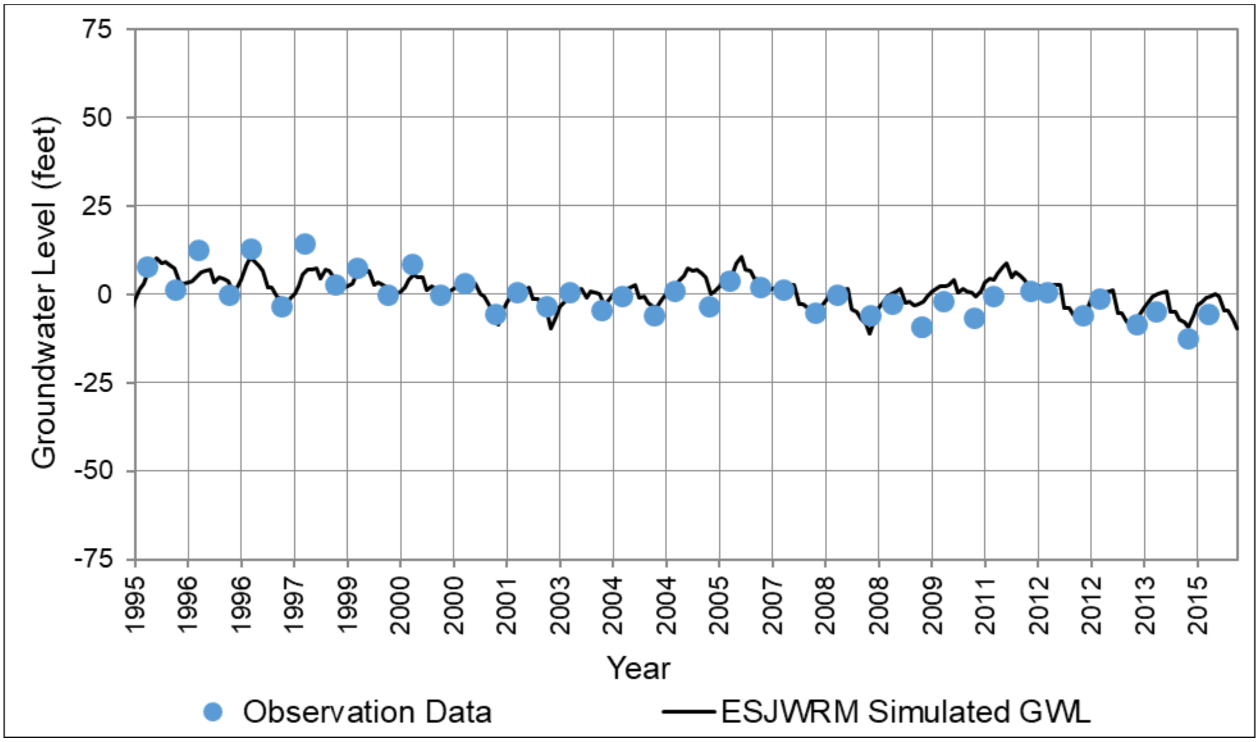


Figure C-6: ESJWRM Groundwater Level Hydrograph – Calibration Well #5

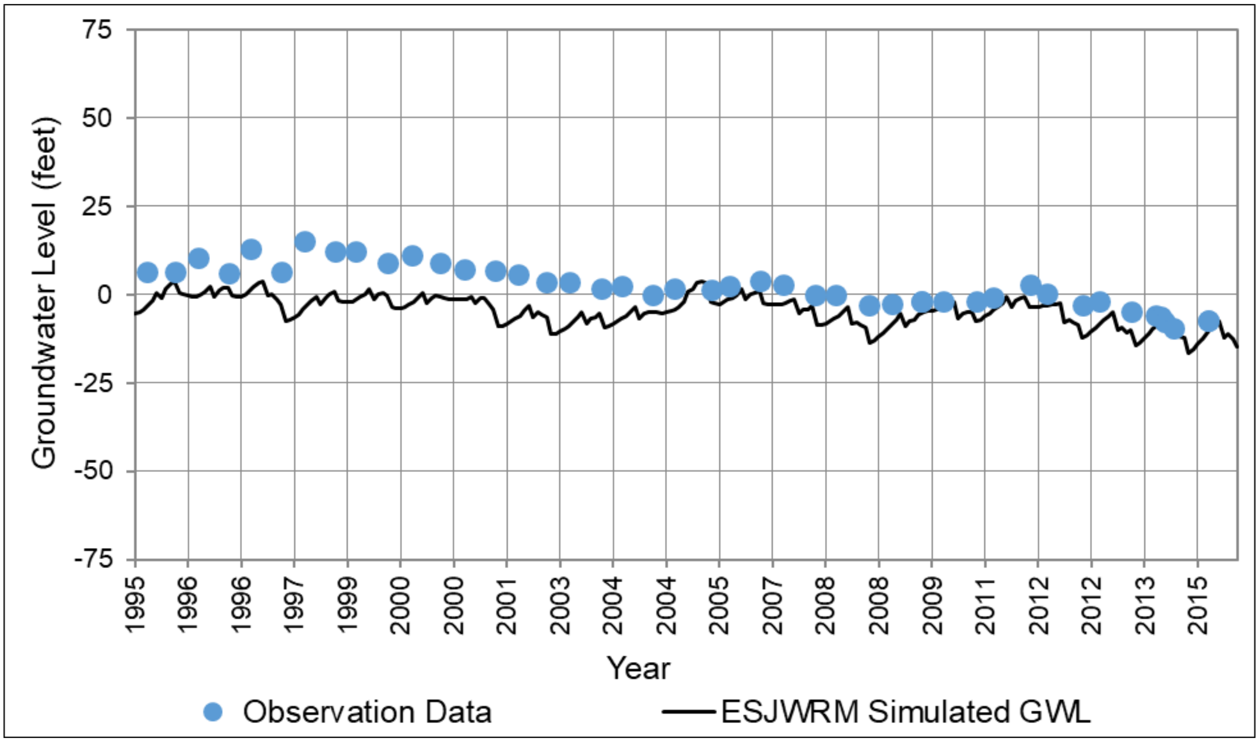


Figure C-7: ESJWRM Groundwater Level Hydrograph – Calibration Well #6

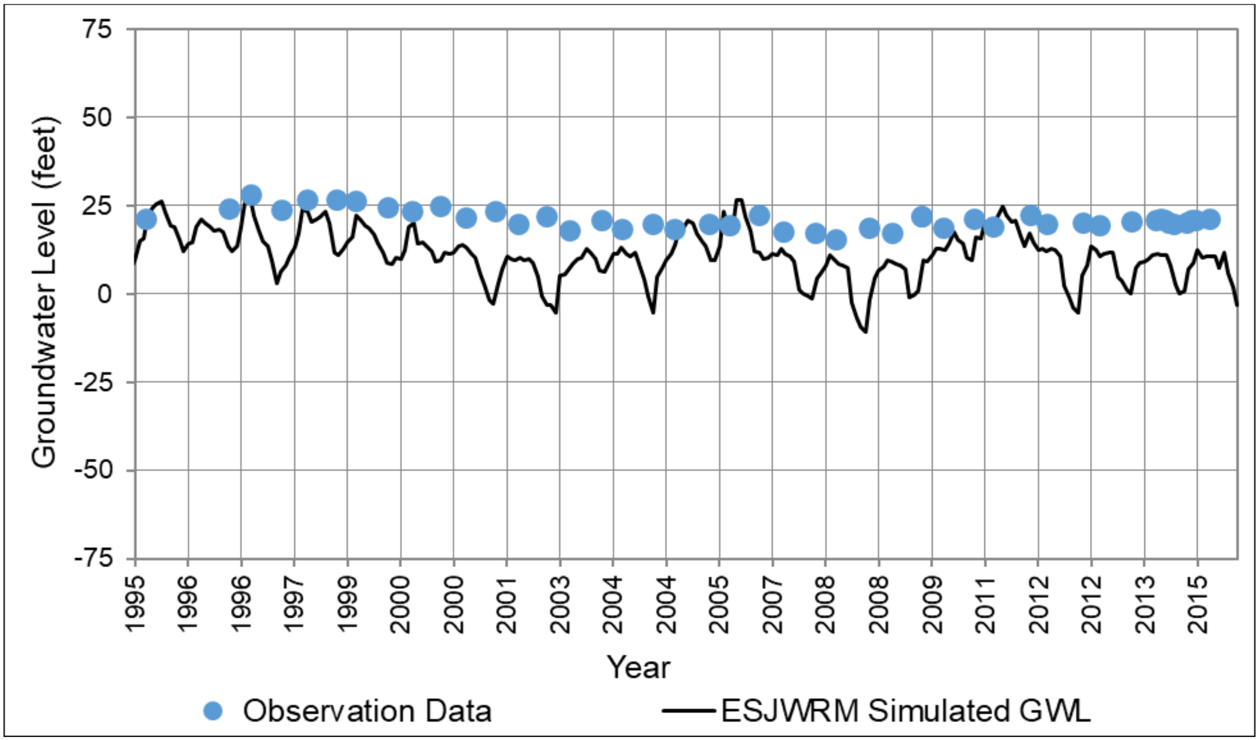


Figure C-8: ESJWRM Groundwater Level Hydrograph – Calibration Well #7

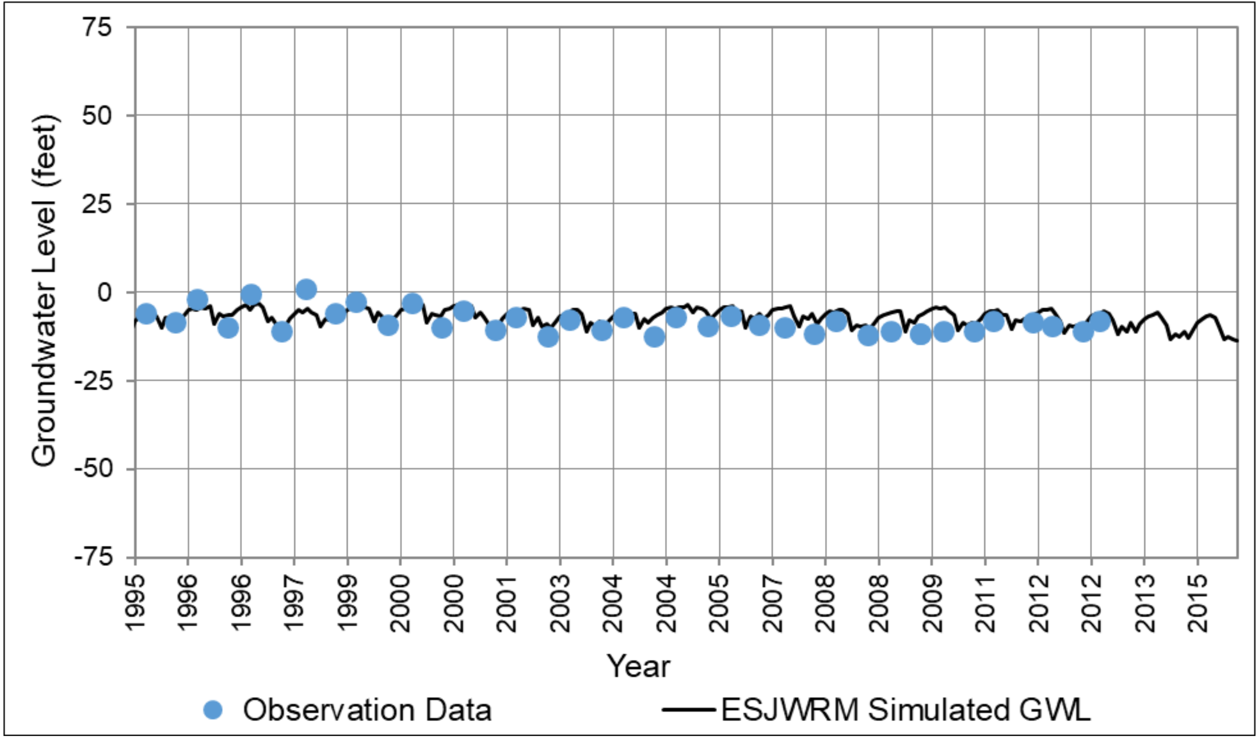


Figure C-9: ESJWRM Groundwater Level Hydrograph – Calibration Well #8

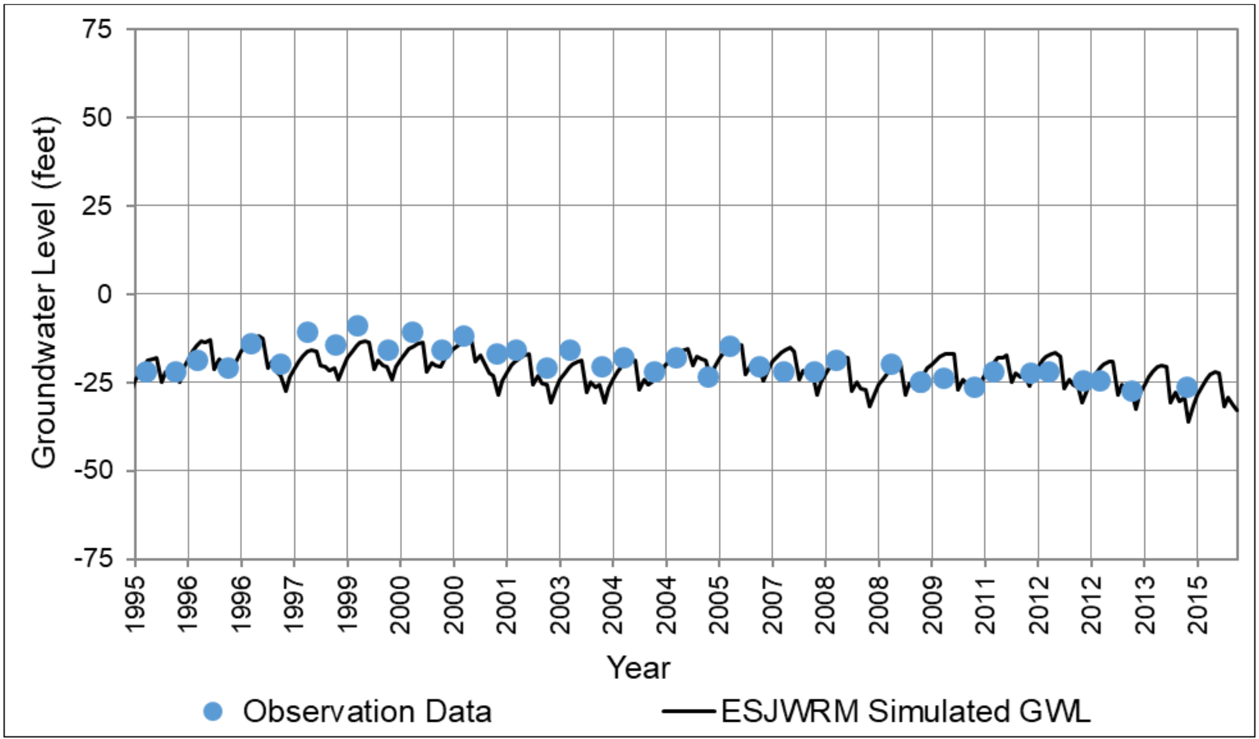


Figure C-10: ESJWRM Groundwater Level Hydrograph – Calibration Well #9

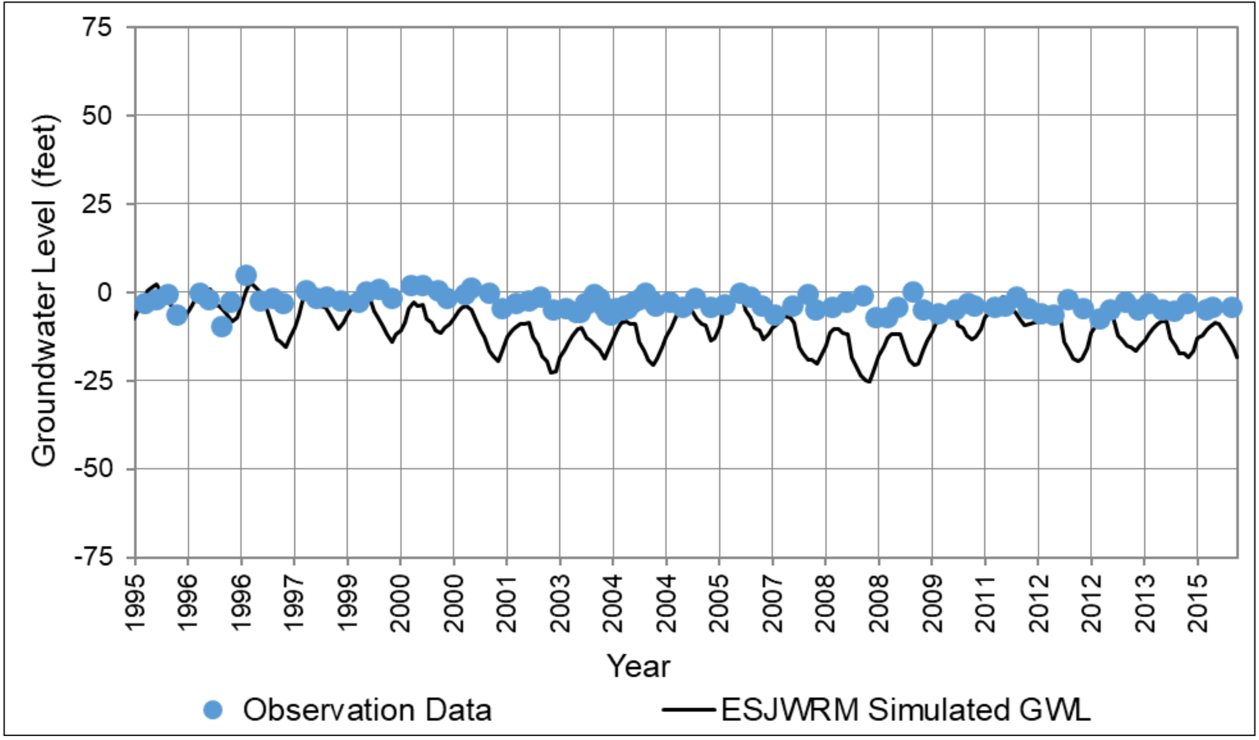


Figure C-11: ESJWRM Groundwater Level Hydrograph – Calibration Well #10

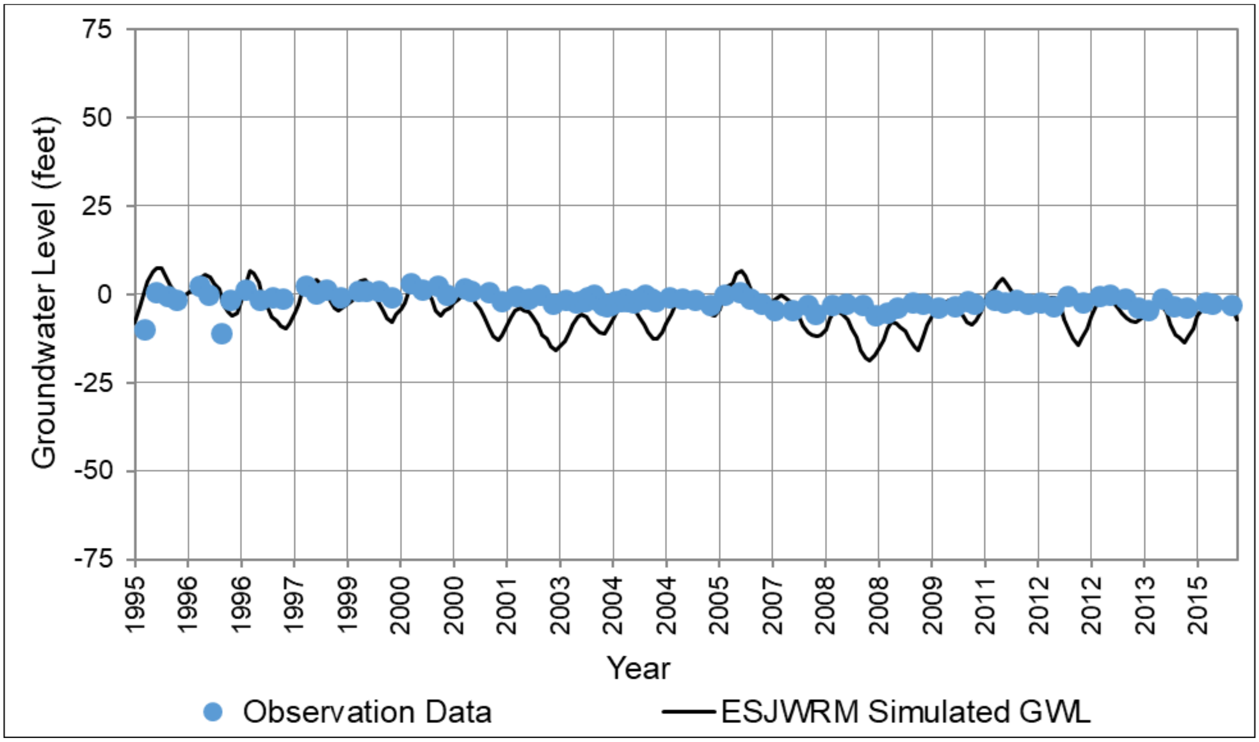


Figure C-12: ESJWRM Groundwater Level Hydrograph – Calibration Well #11

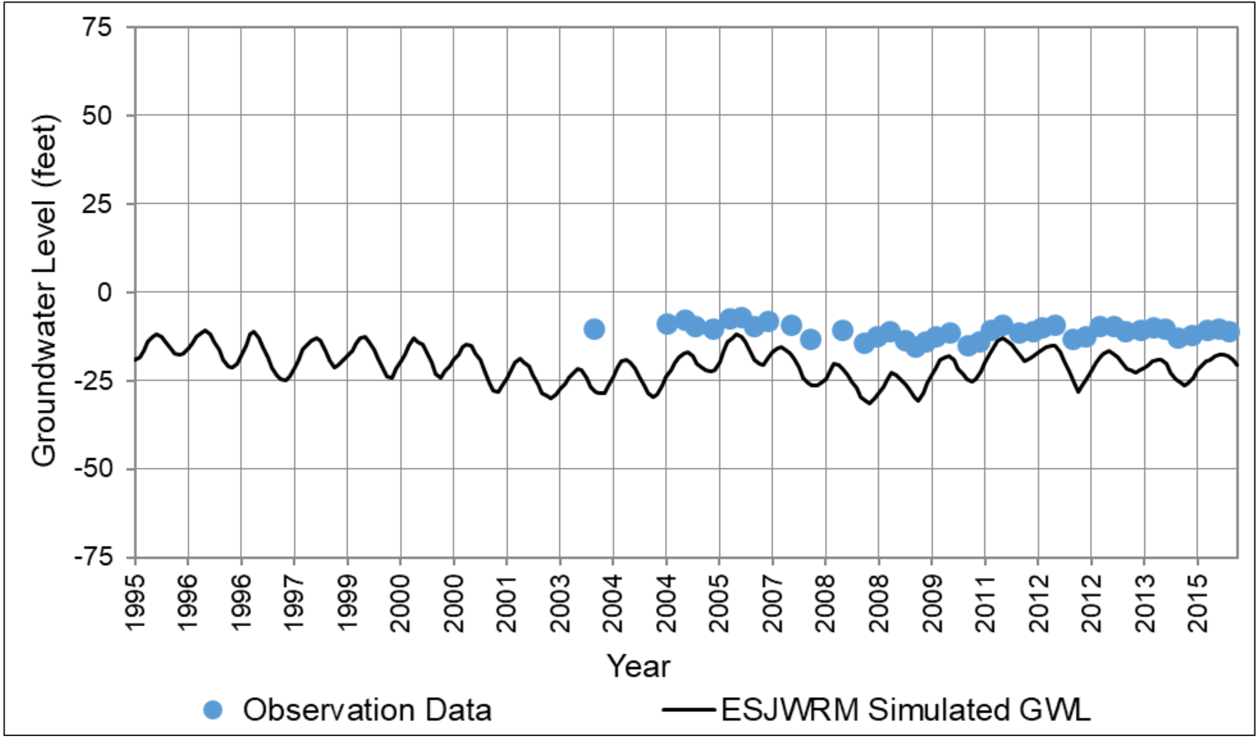


Figure C-13: ESJWRM Groundwater Level Hydrograph – Calibration Well #12

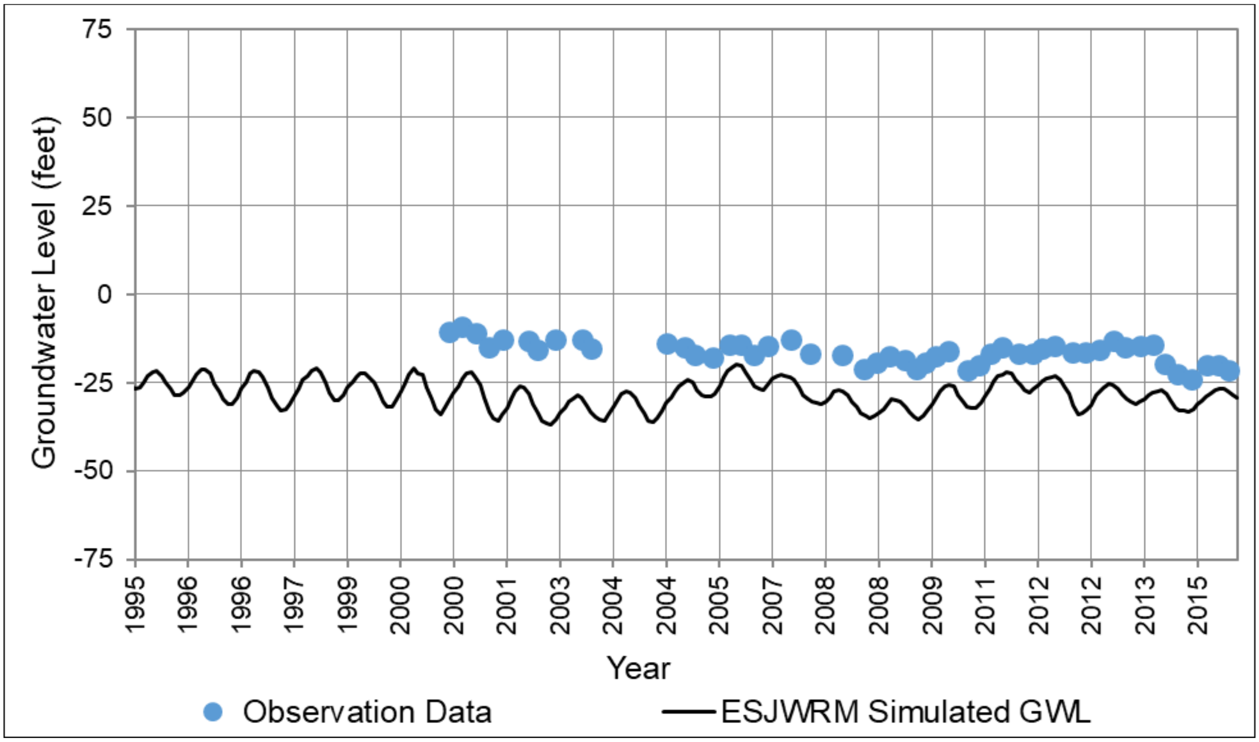


Figure C-14: ESJWRM Groundwater Level Hydrograph – Calibration Well #13

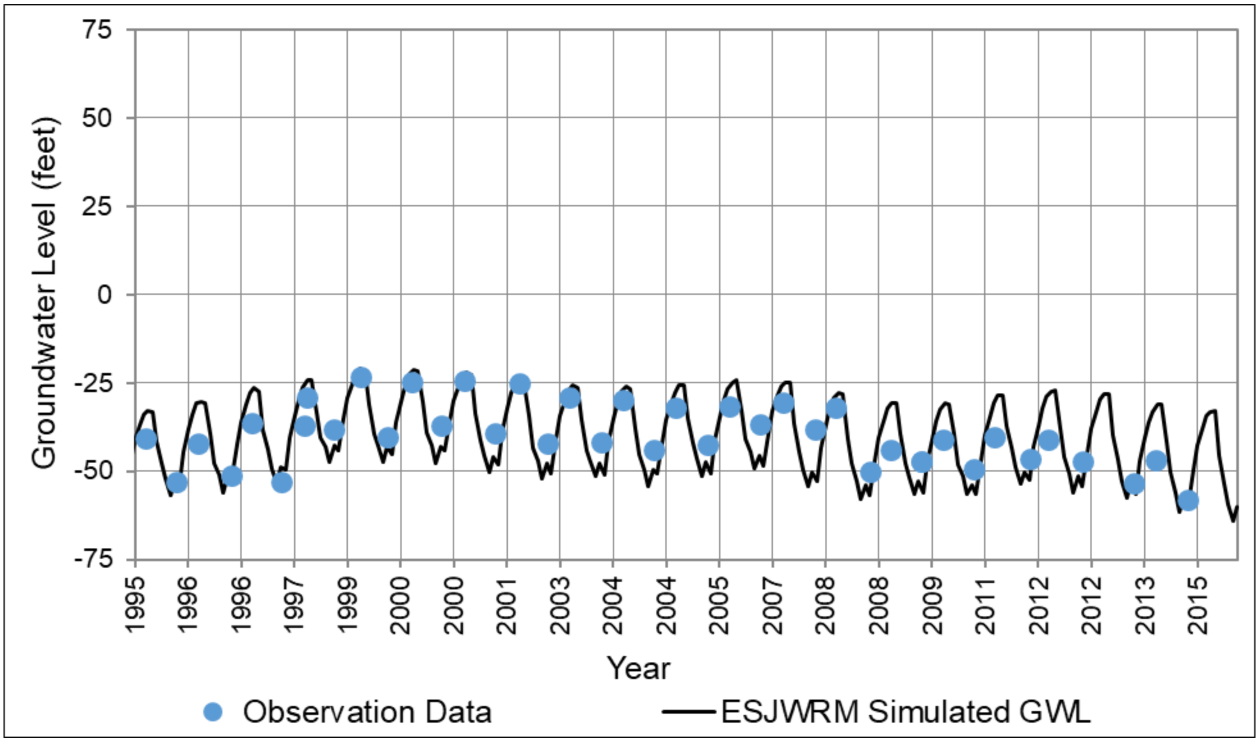


Figure C-15: ESJWRM Groundwater Level Hydrograph – Calibration Well #14

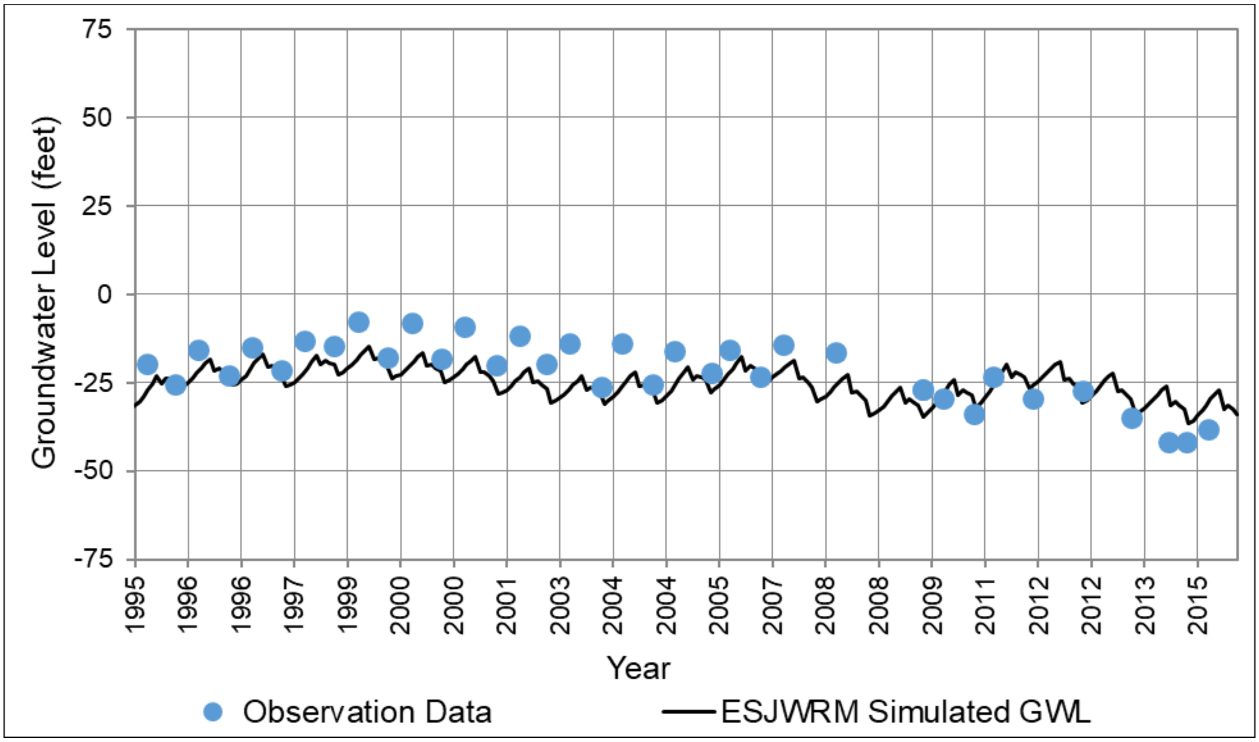


Figure C-16: ESJWRM Groundwater Level Hydrograph – Calibration Well #15

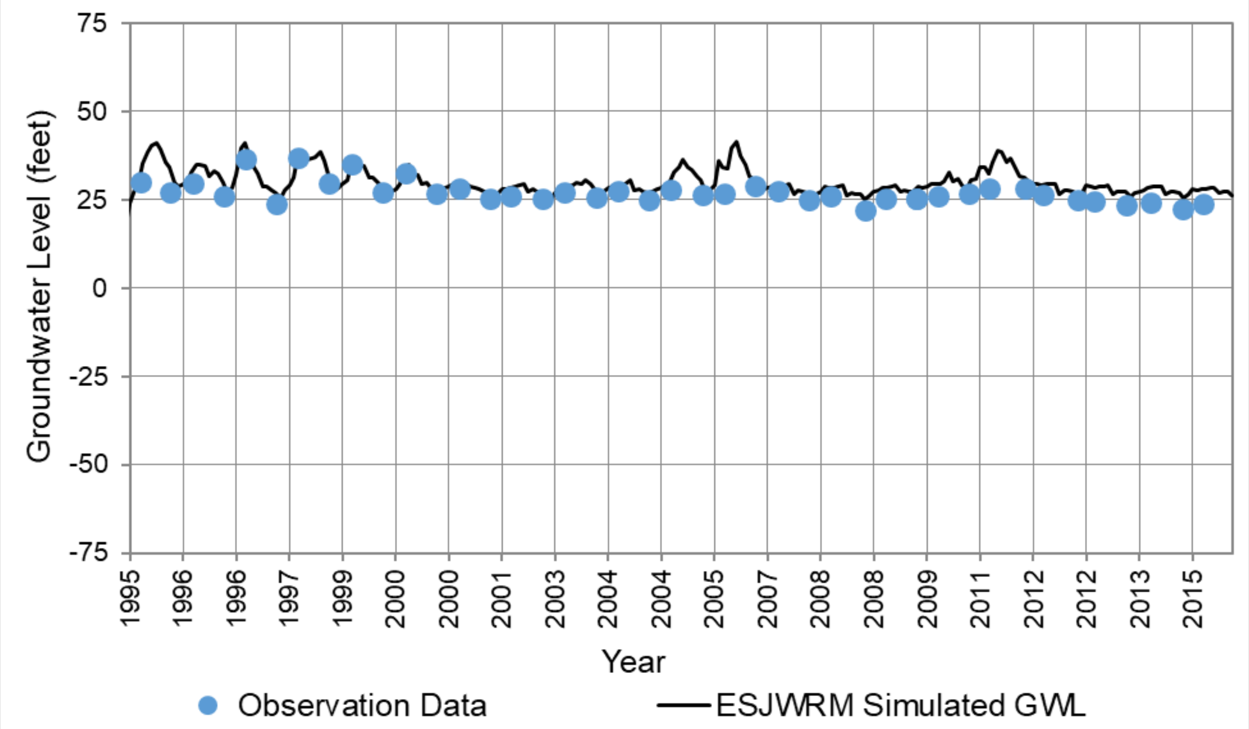


Figure C-17: ESJWRM Groundwater Level Hydrograph – Calibration Well #16

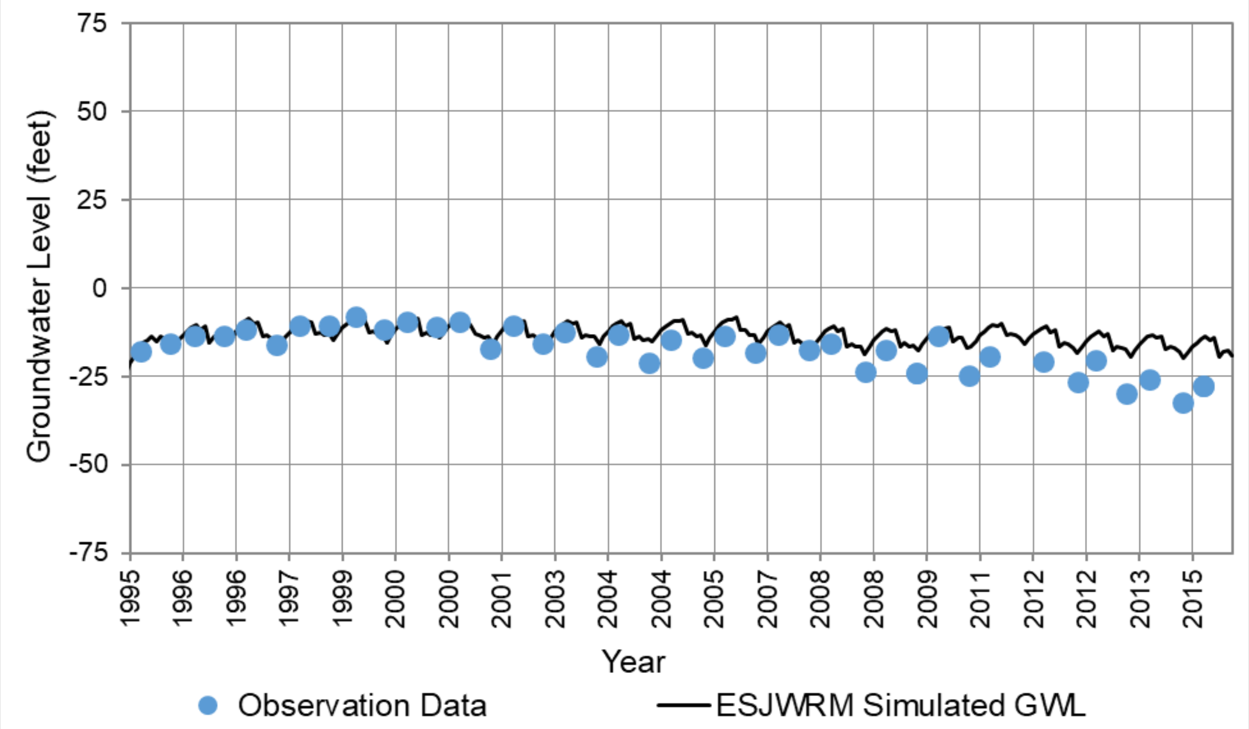


Figure C-18: ESJWRM Groundwater Level Hydrograph – Calibration Well #17

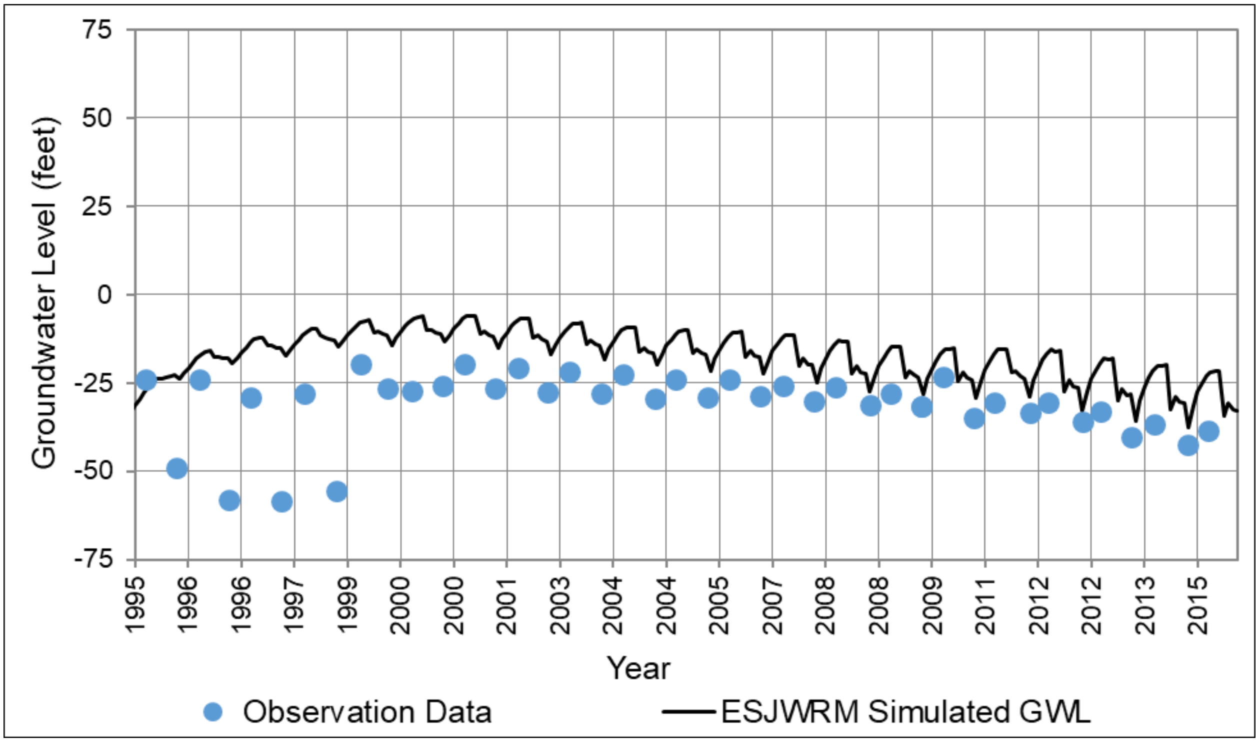


Figure C-19: ESJWRM Groundwater Level Hydrograph – Calibration Well #18

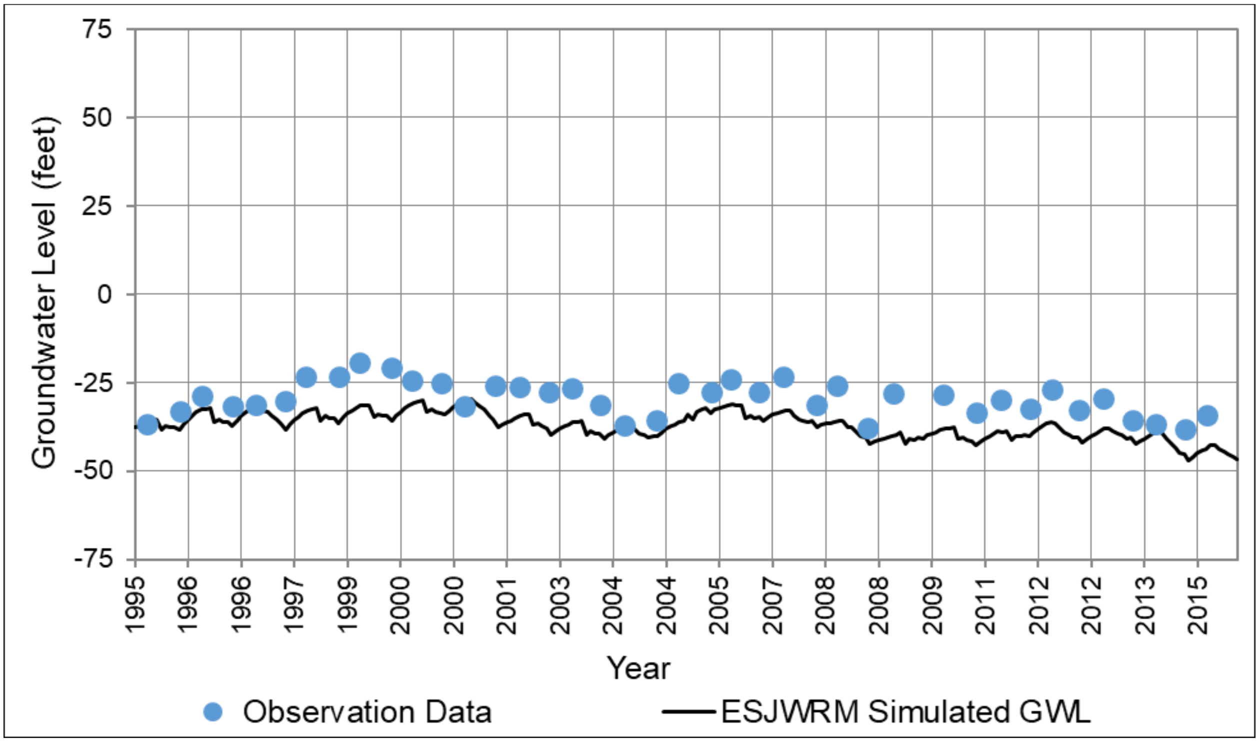


Figure C-20: ESJWRM Groundwater Level Hydrograph – Calibration Well #19

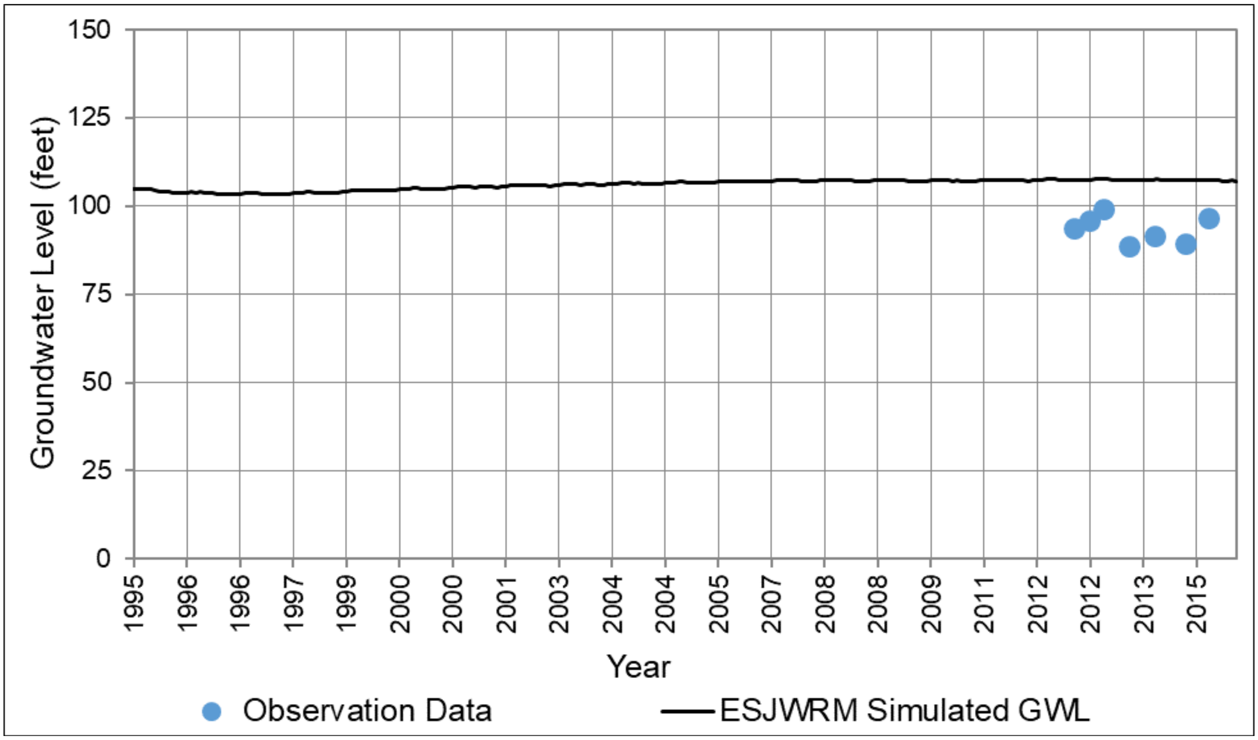


Figure C-21: ESJWRM Groundwater Level Hydrograph – Calibration Well #20

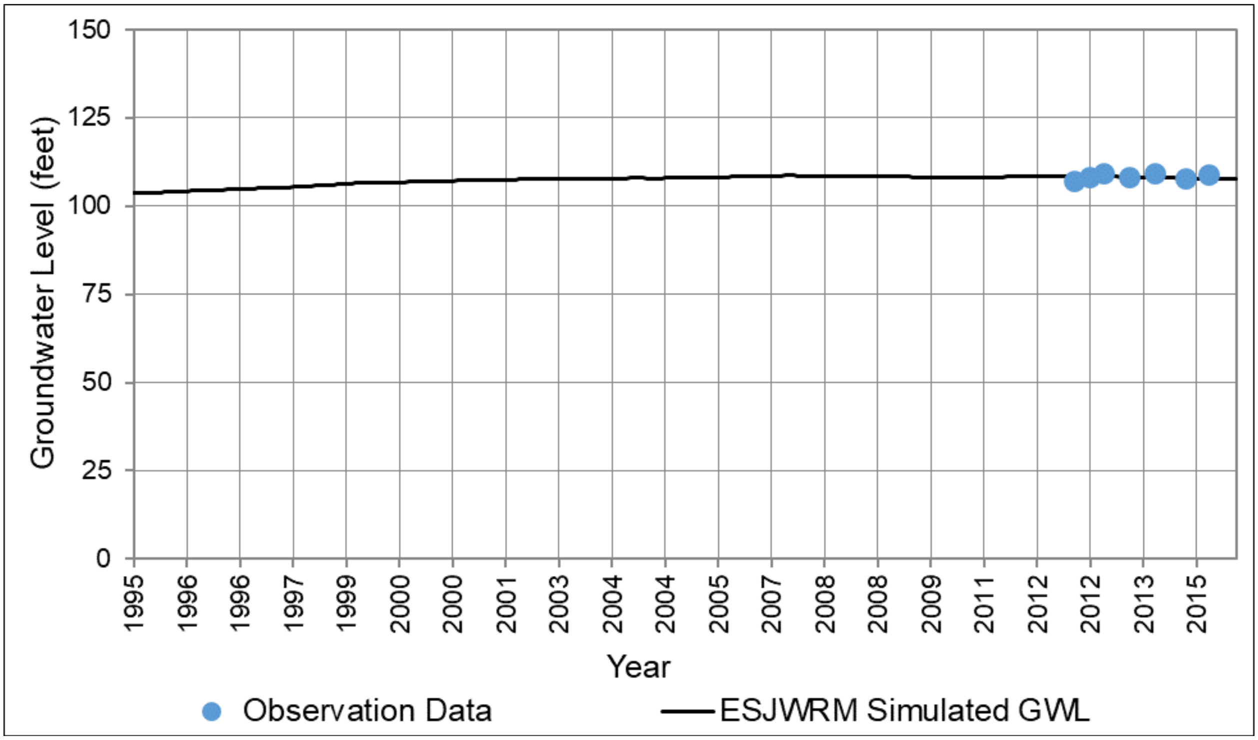


Figure C-22: ESJWRM Groundwater Level Hydrograph – Calibration Well #21

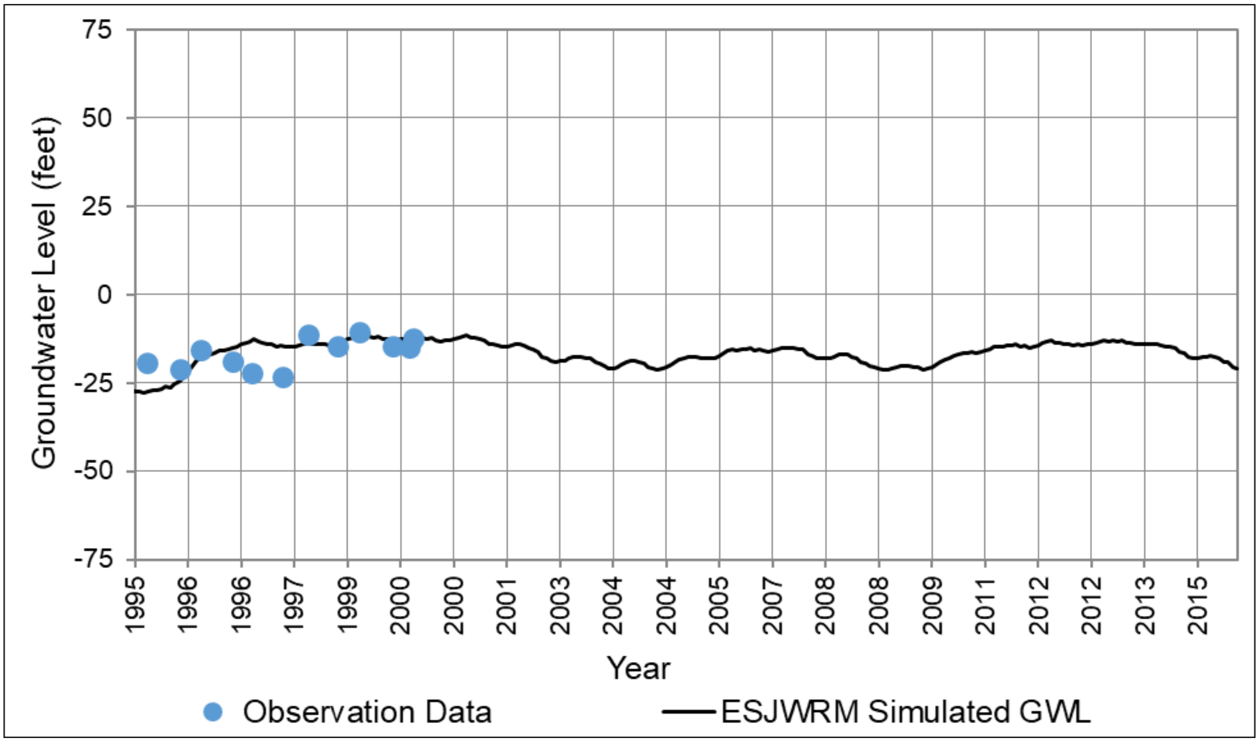


Figure C-23: ESJWRM Groundwater Level Hydrograph – Calibration Well #22

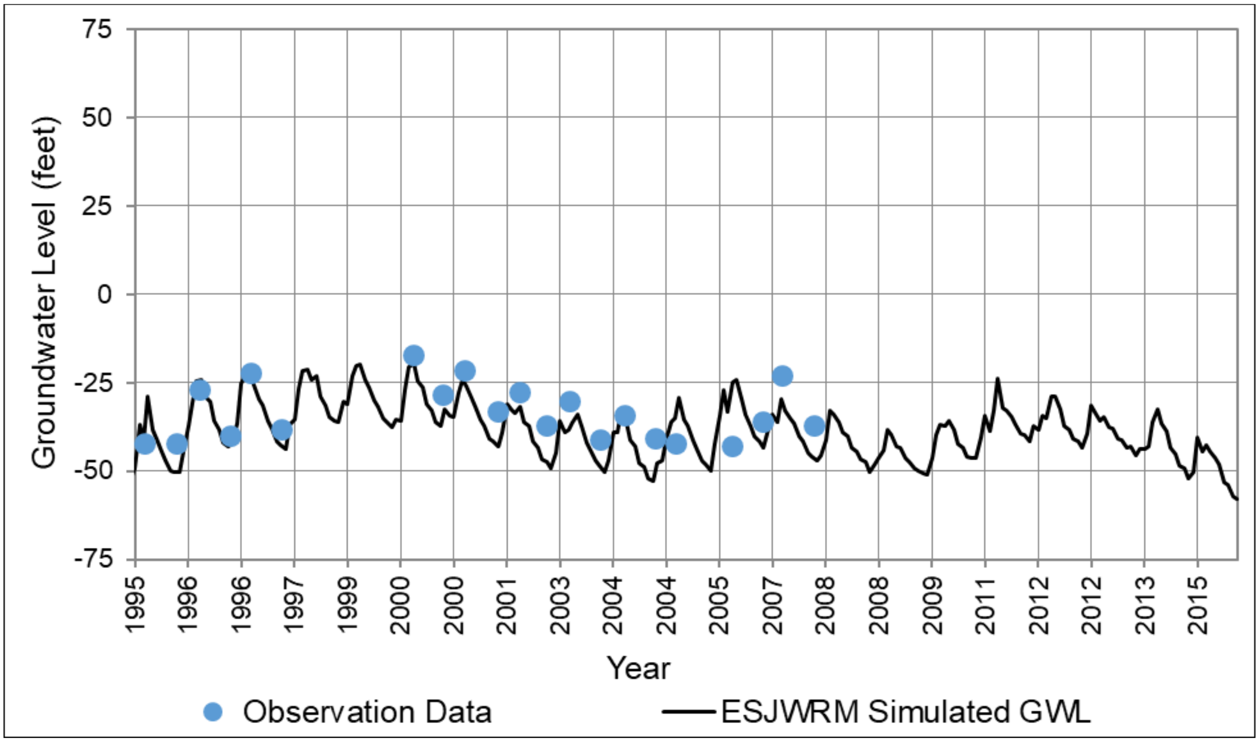


Figure C-24: ESJWRM Groundwater Level Hydrograph – Calibration Well #23

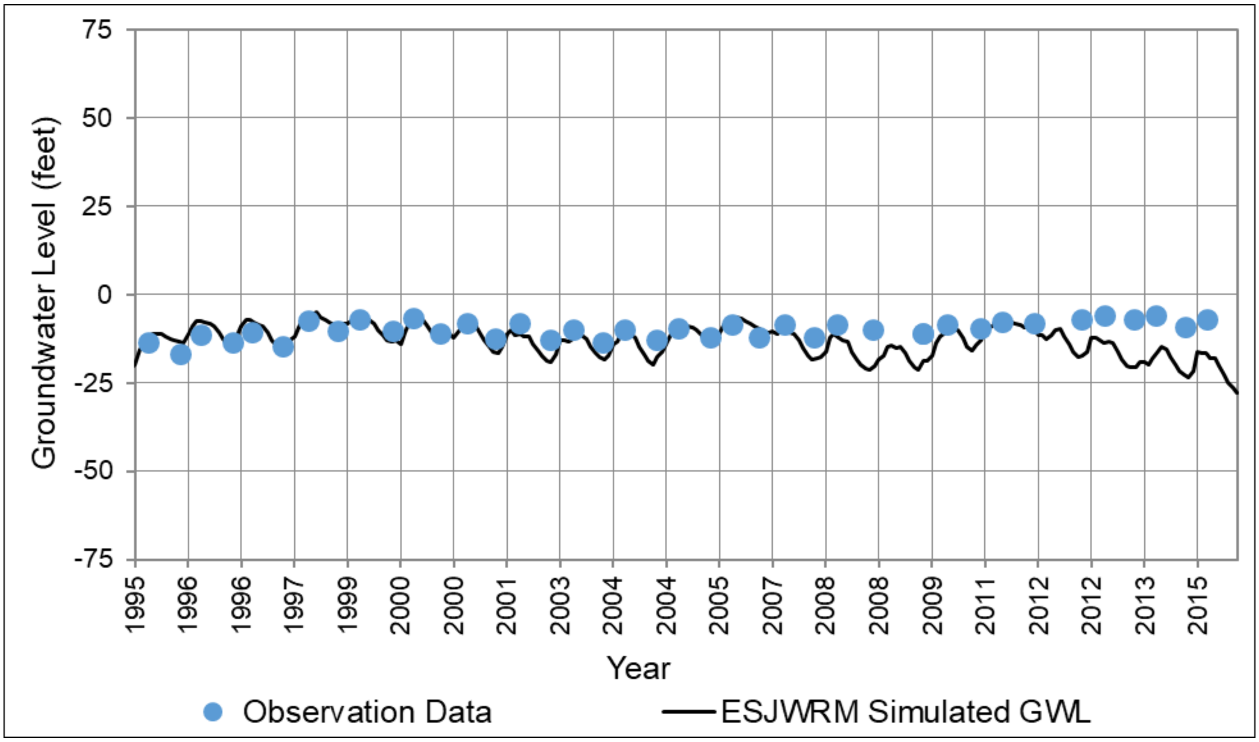


Figure C-25: ESJWRM Groundwater Level Hydrograph – Calibration Well #24

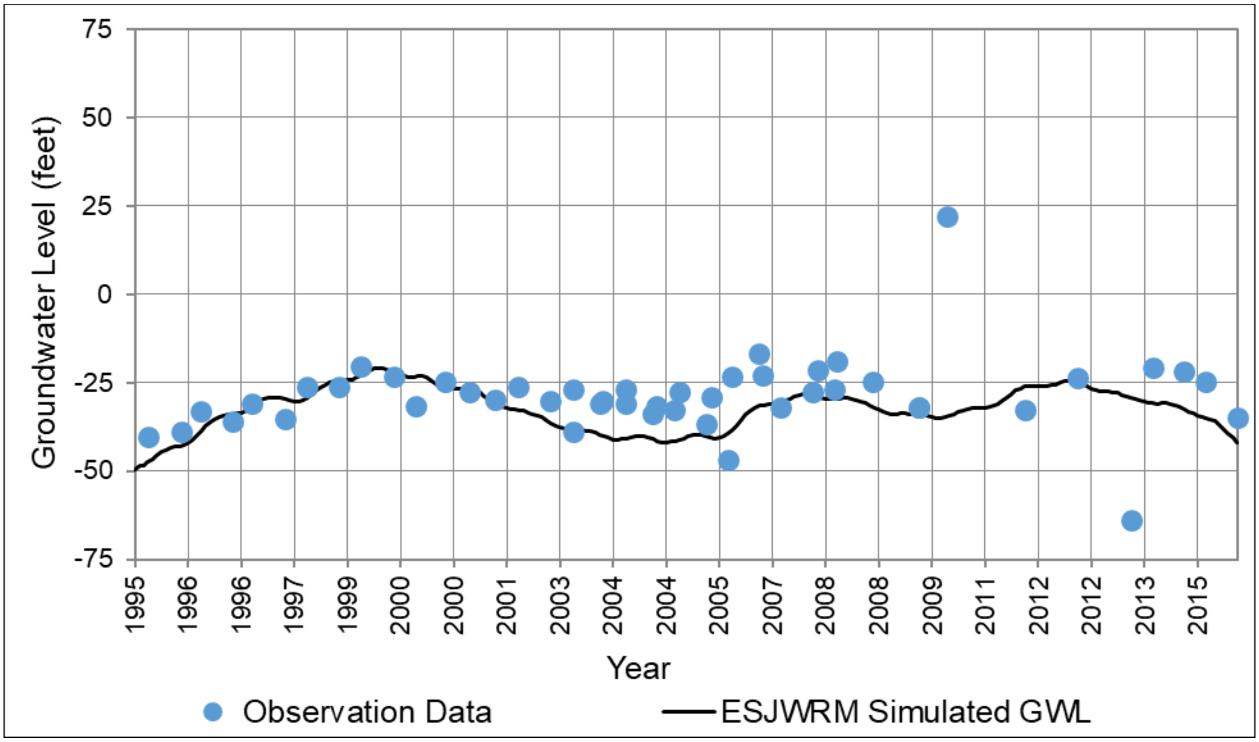


Figure C-26: ESJWRM Groundwater Level Hydrograph – Calibration Well #25

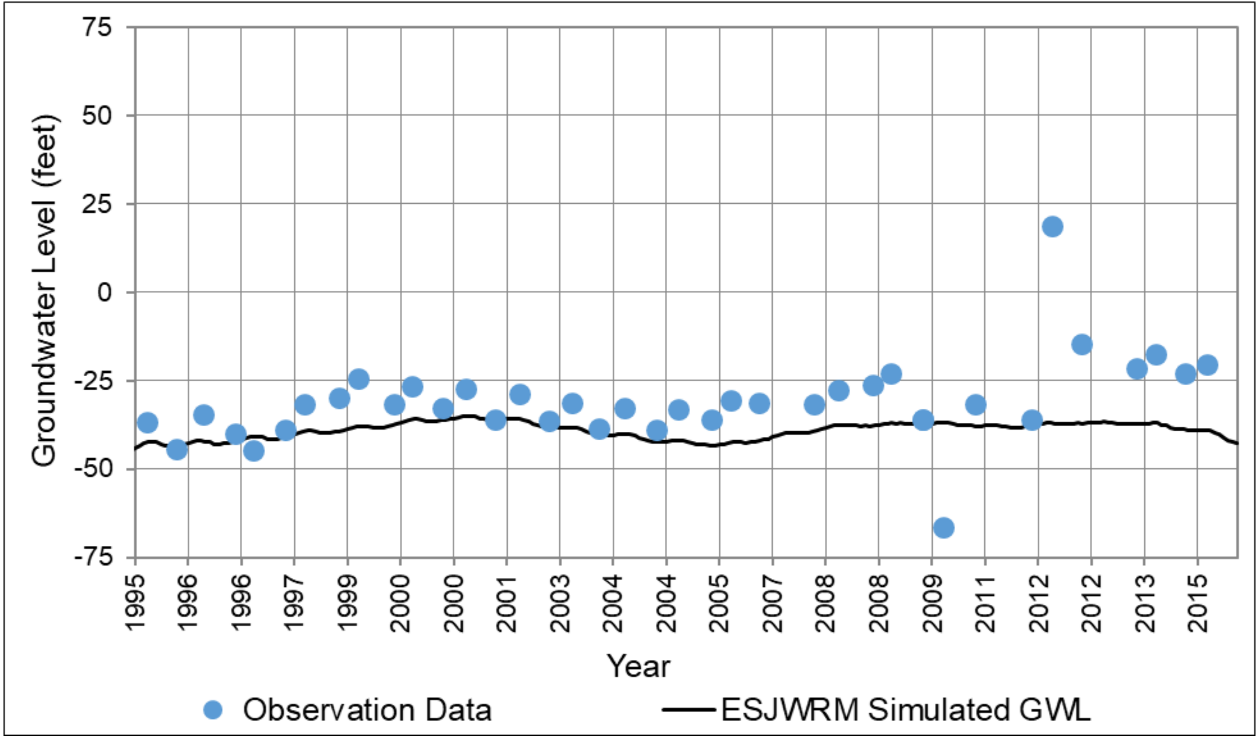


Figure C-27: ESJWRM Groundwater Level Hydrograph – Calibration Well #26

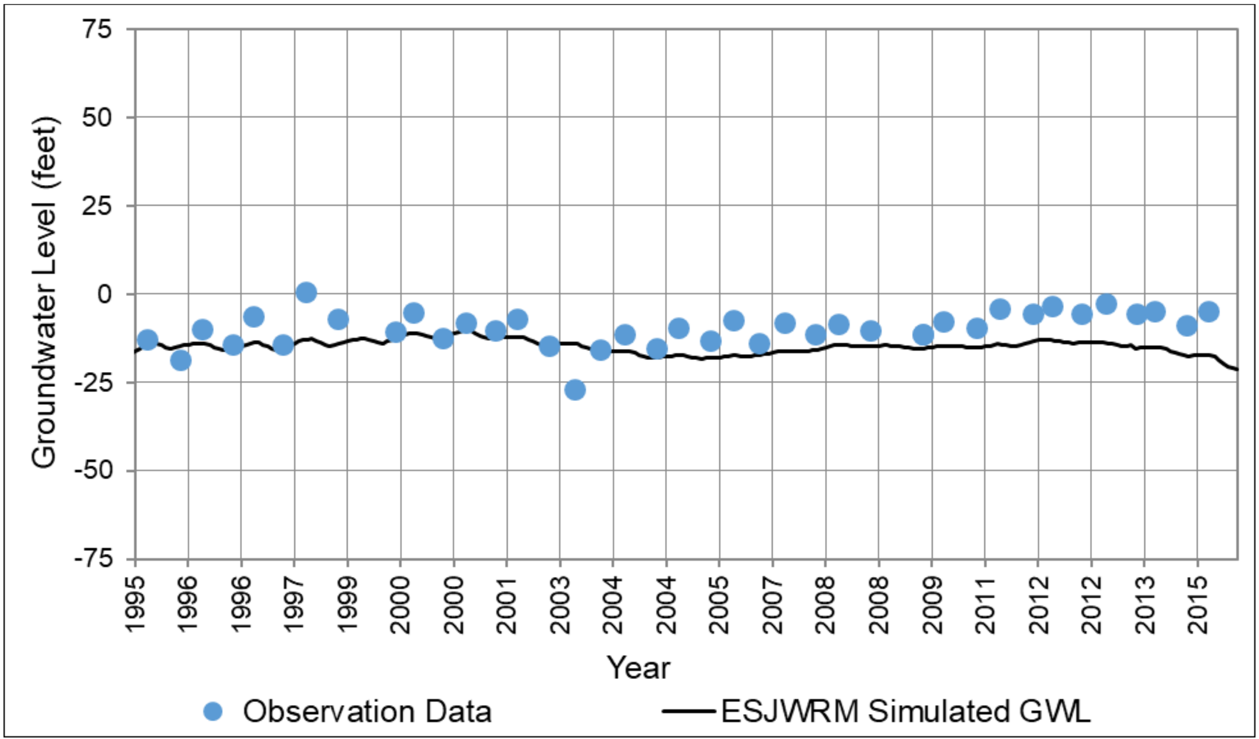


Figure C-28: ESJWRM Groundwater Level Hydrograph – Calibration Well #27

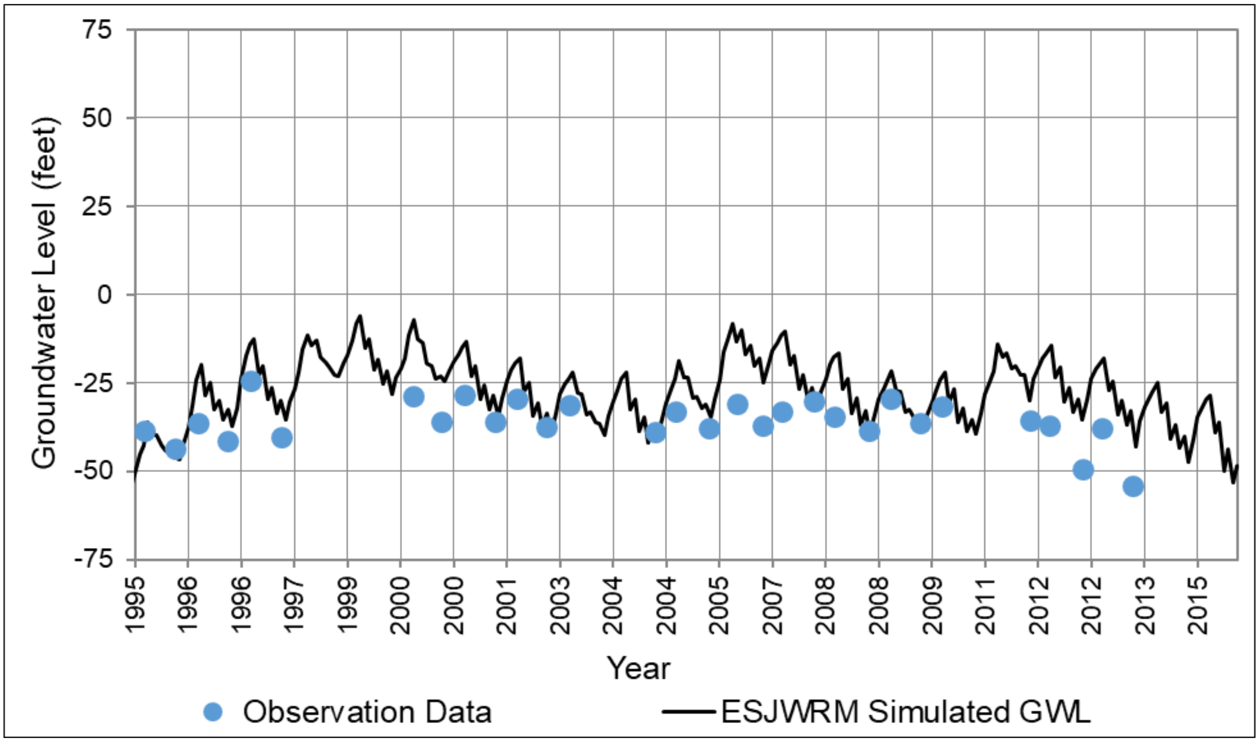


Figure C-29: ESJWRM Groundwater Level Hydrograph – Calibration Well #28

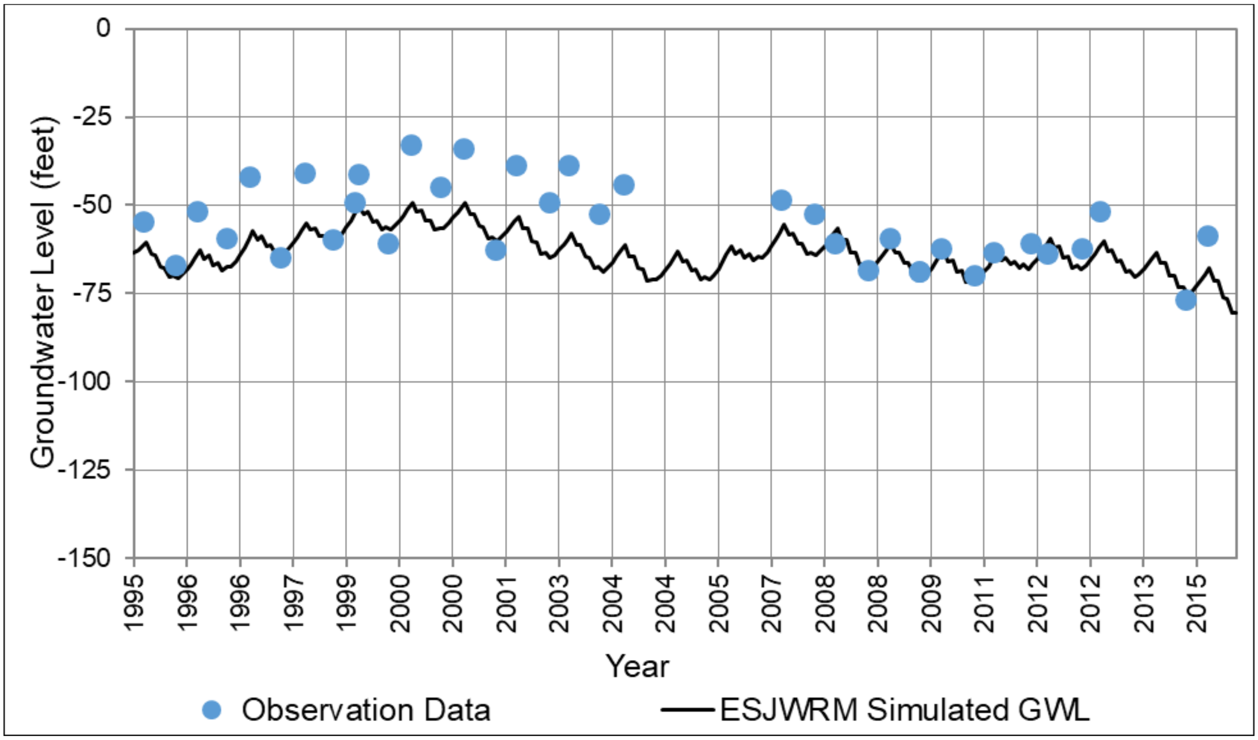


Figure C-30: ESJWRM Groundwater Level Hydrograph – Calibration Well #29

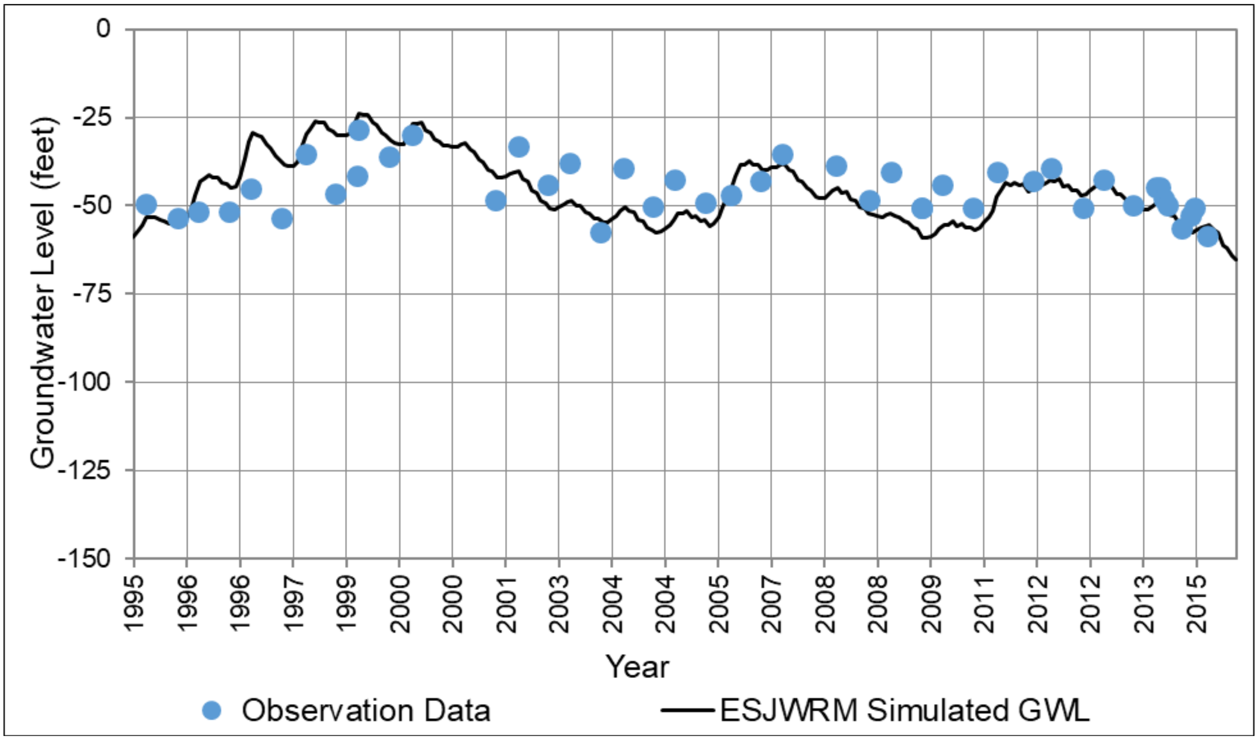


Figure C-31: ESJWRM Groundwater Level Hydrograph – Calibration Well #30

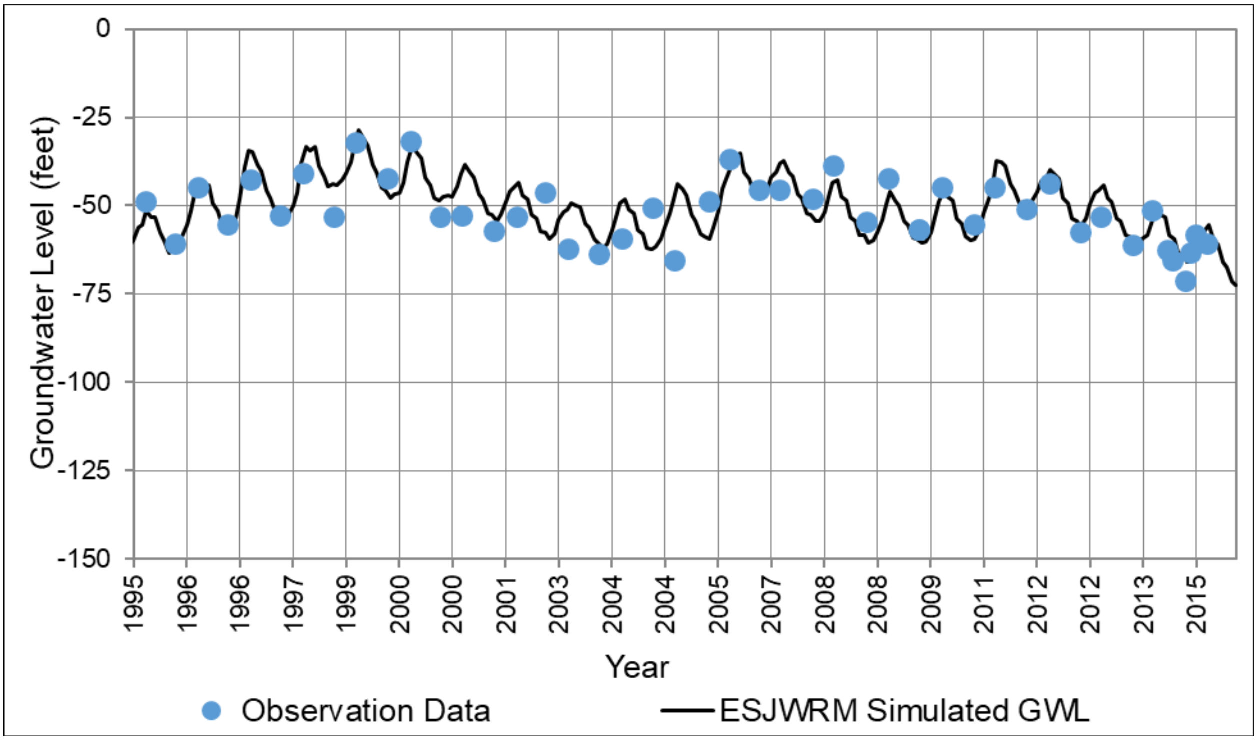


Figure C-32: ESJWRM Groundwater Level Hydrograph – Calibration Well #31

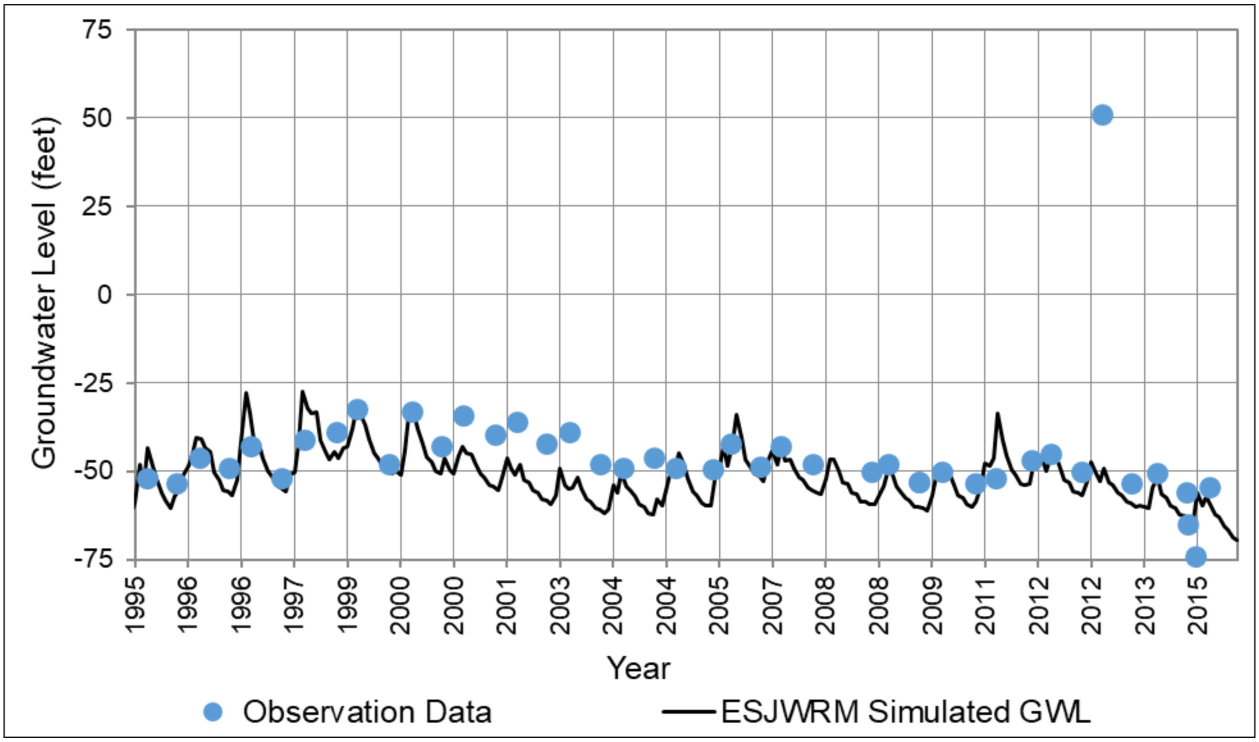


Figure C-33: ESJWRM Groundwater Level Hydrograph – Calibration Well #32

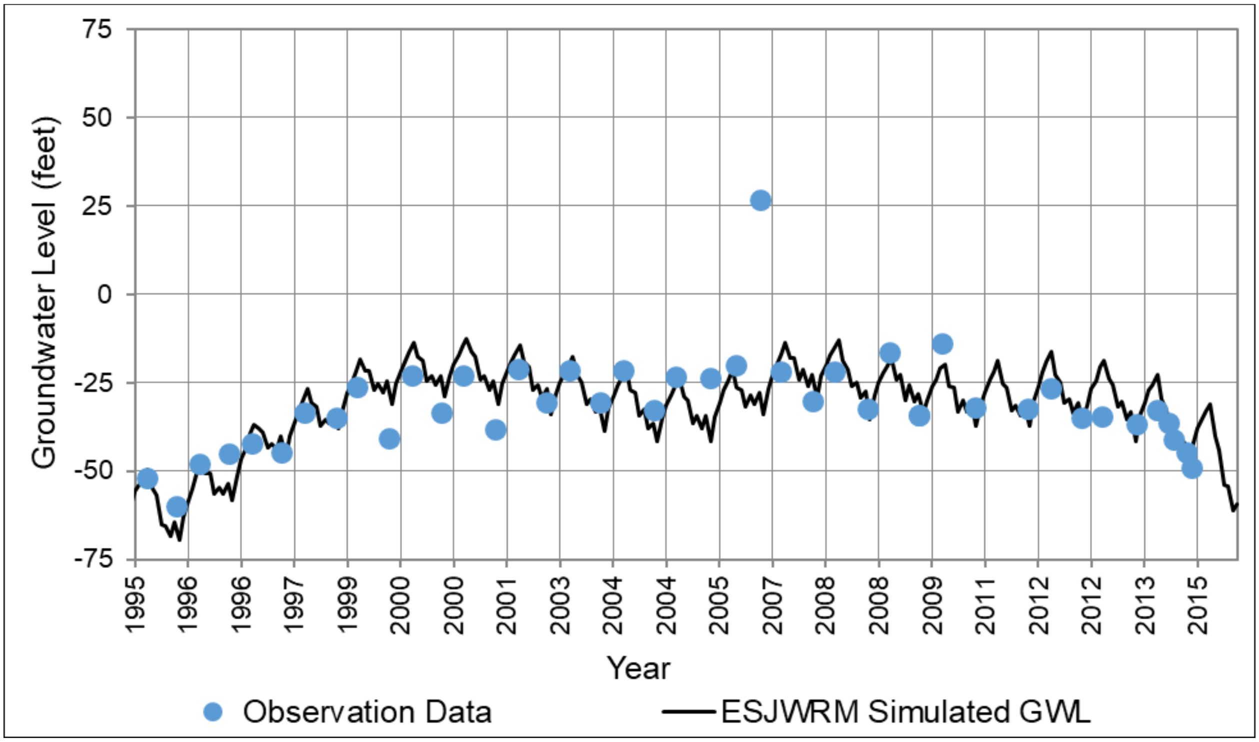


Figure C-34: ESJWRM Groundwater Level Hydrograph – Calibration Well #33

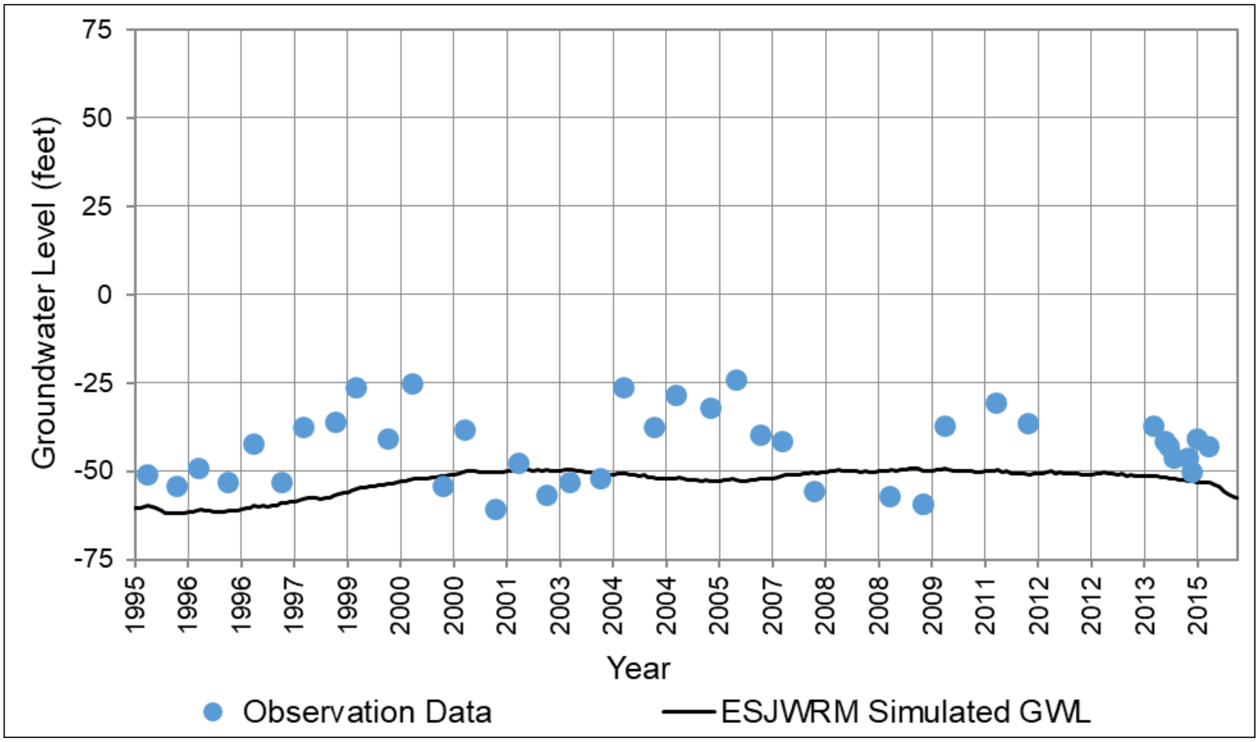


Figure C-35: ESJWRM Groundwater Level Hydrograph – Calibration Well #34

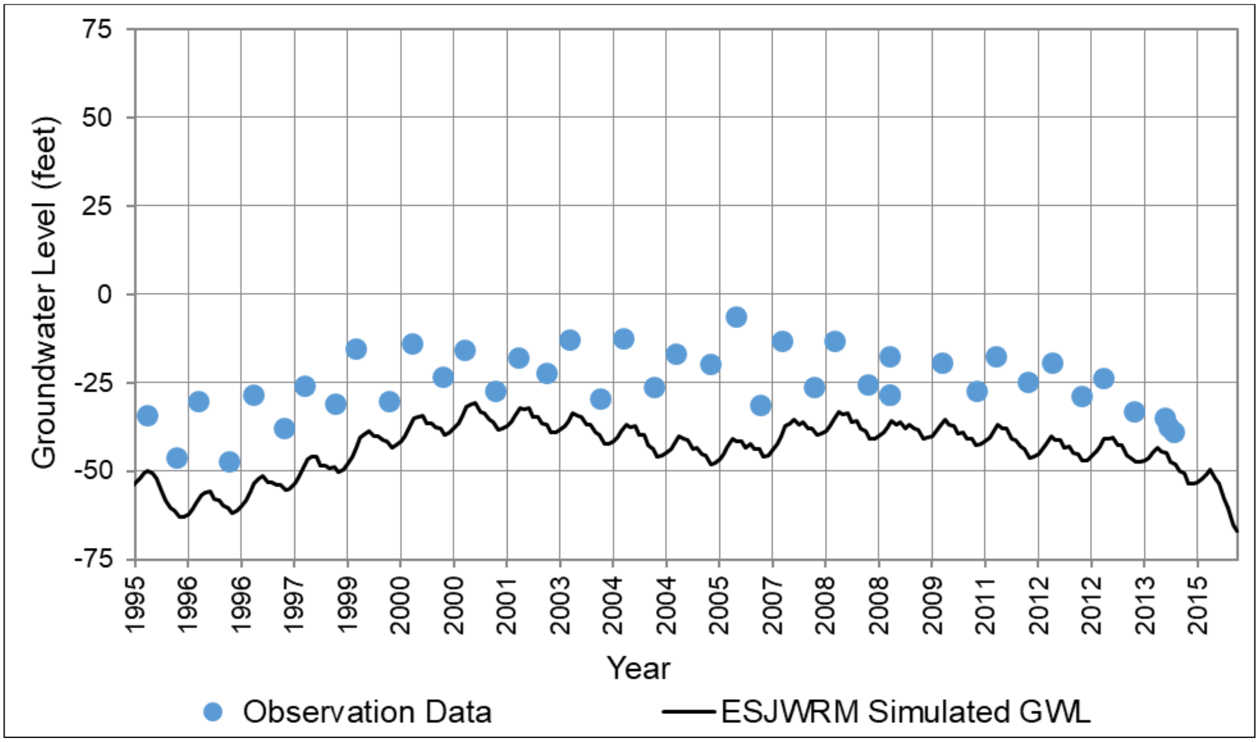


Figure C-36: ESJWRM Groundwater Level Hydrograph – Calibration Well #35

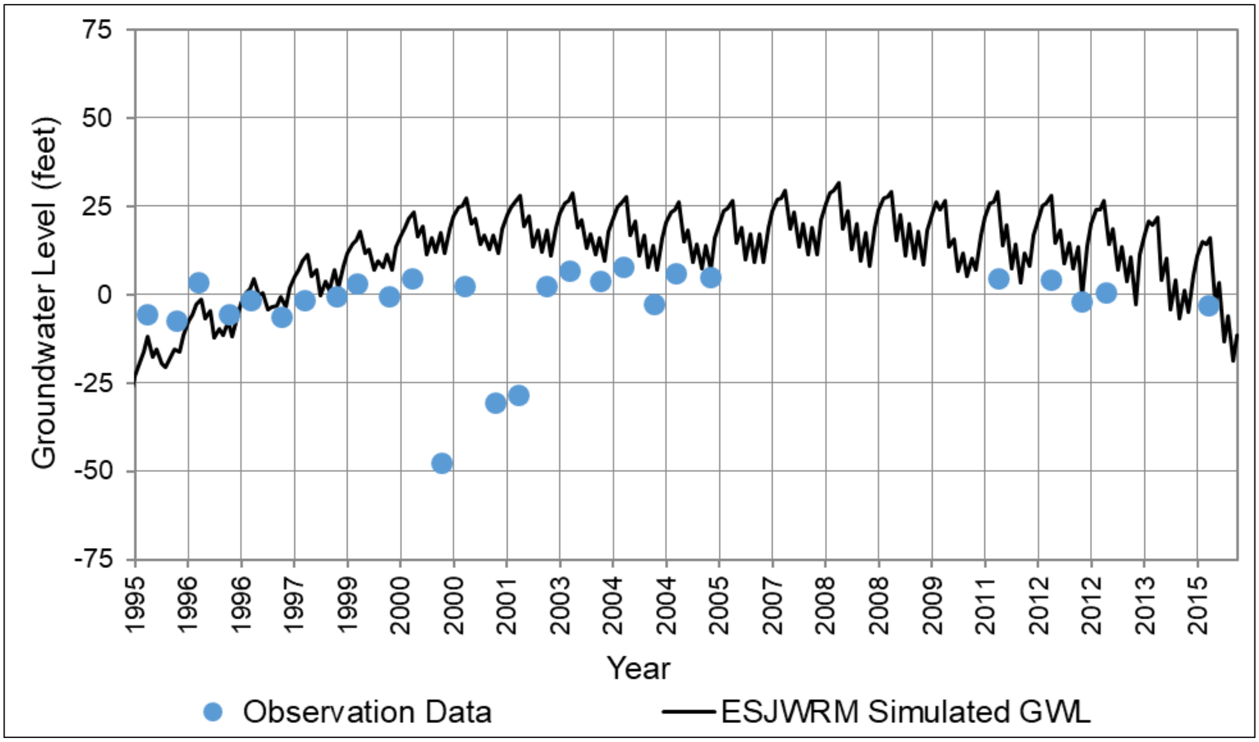


Figure C-37: ESJWRM Groundwater Level Hydrograph – Calibration Well #36

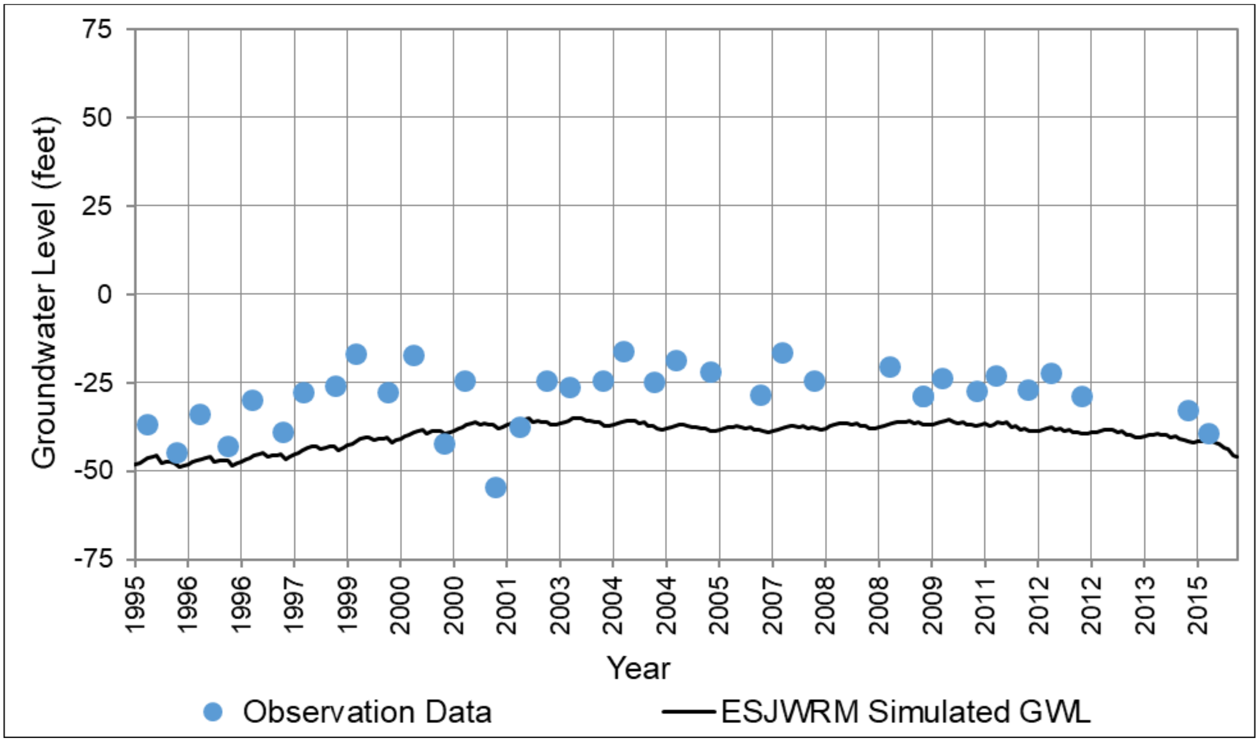


Figure C-38: ESJWRM Groundwater Level Hydrograph – Calibration Well #37

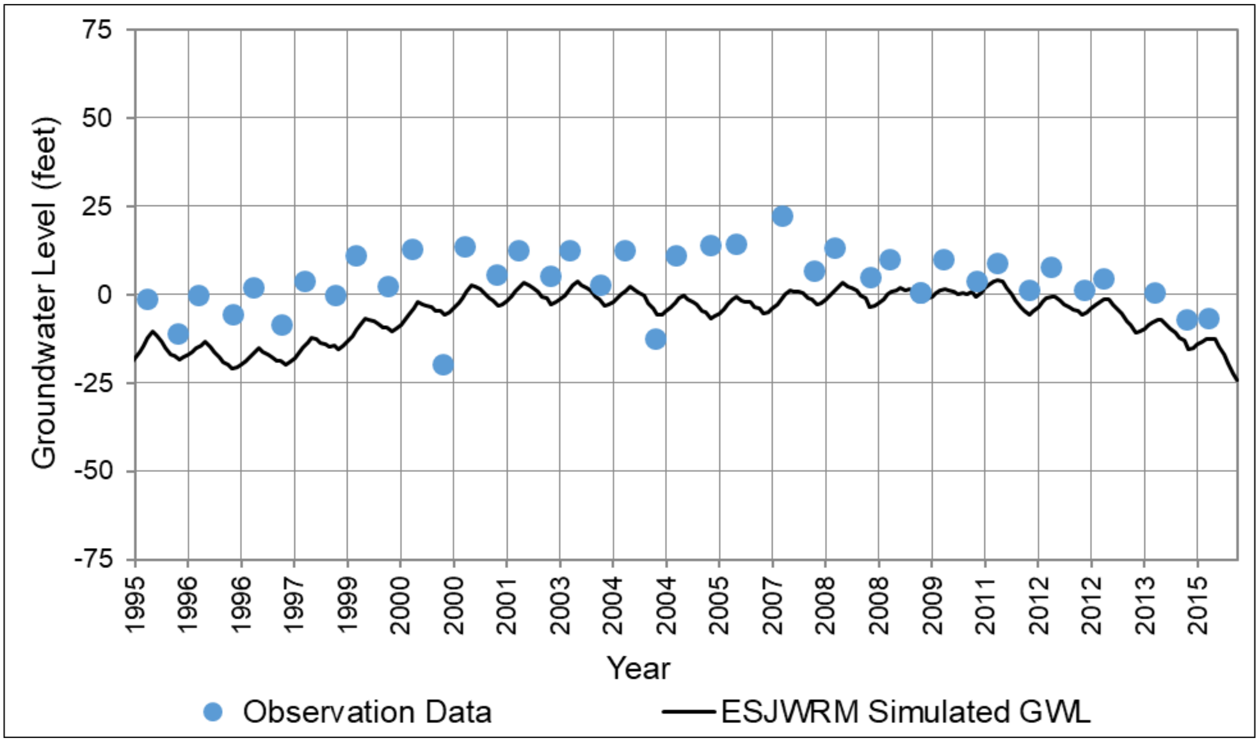


Figure C-39: ESJWRM Groundwater Level Hydrograph – Calibration Well #38

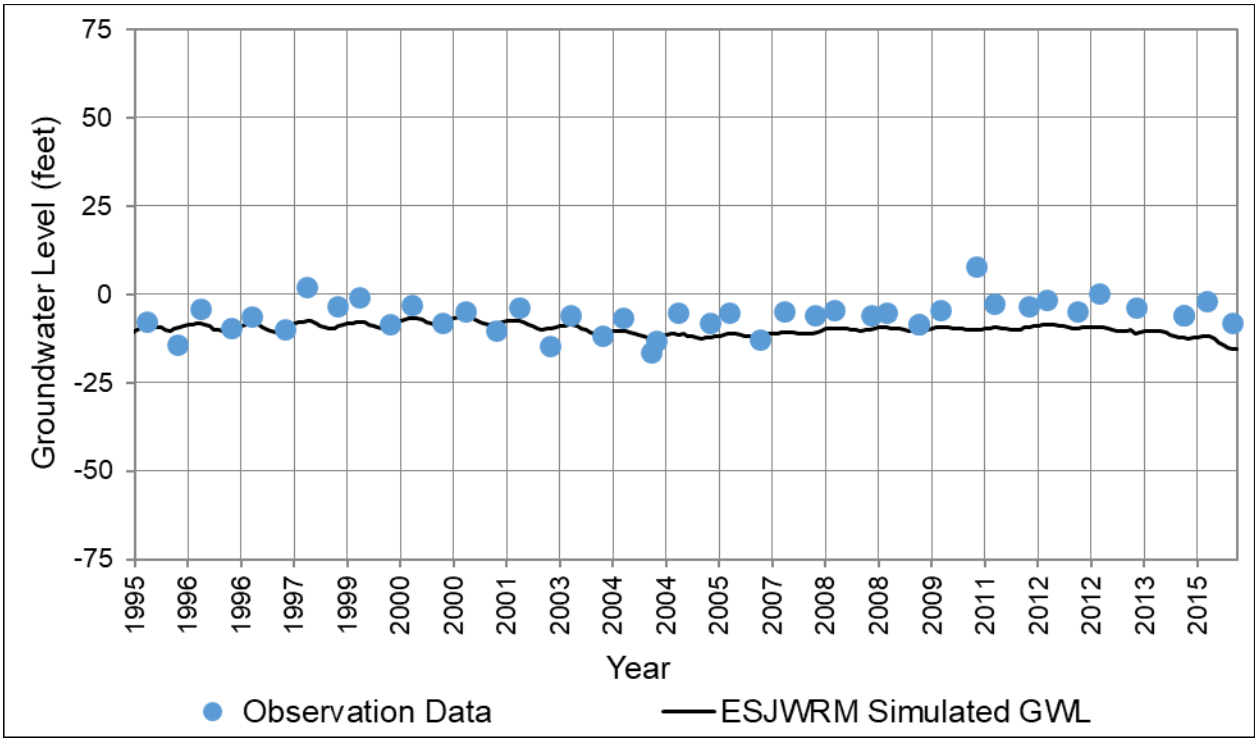


Figure C-40: ESJWRM Groundwater Level Hydrograph – Calibration Well #39

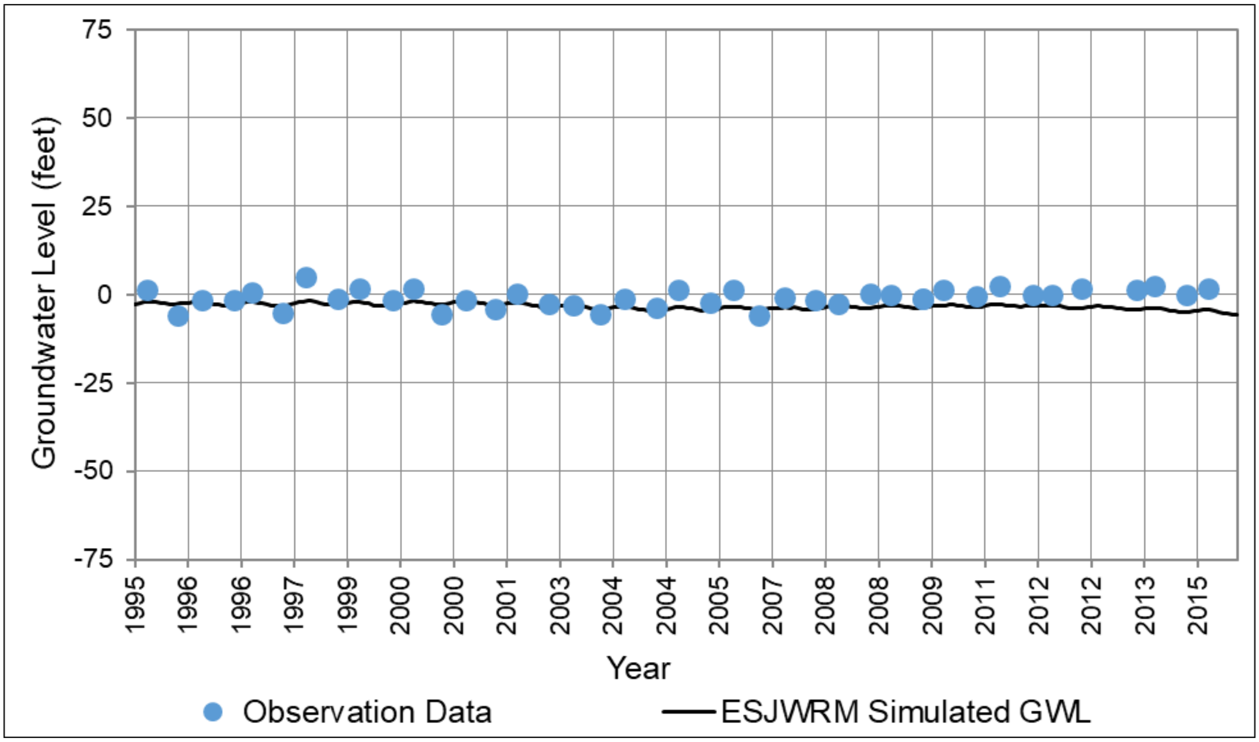


Figure C-41: ESJWRM Groundwater Level Hydrograph – Calibration Well #40

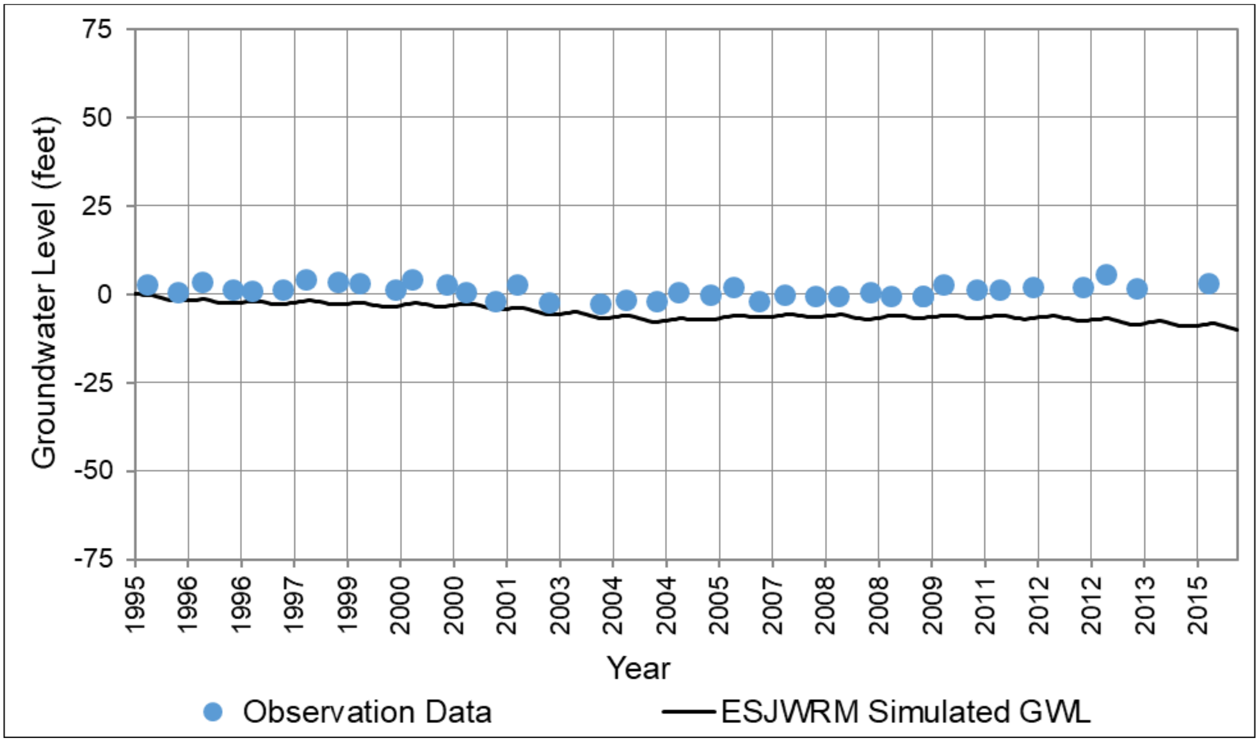


Figure C-42: ESJWRM Groundwater Level Hydrograph – Calibration Well #41

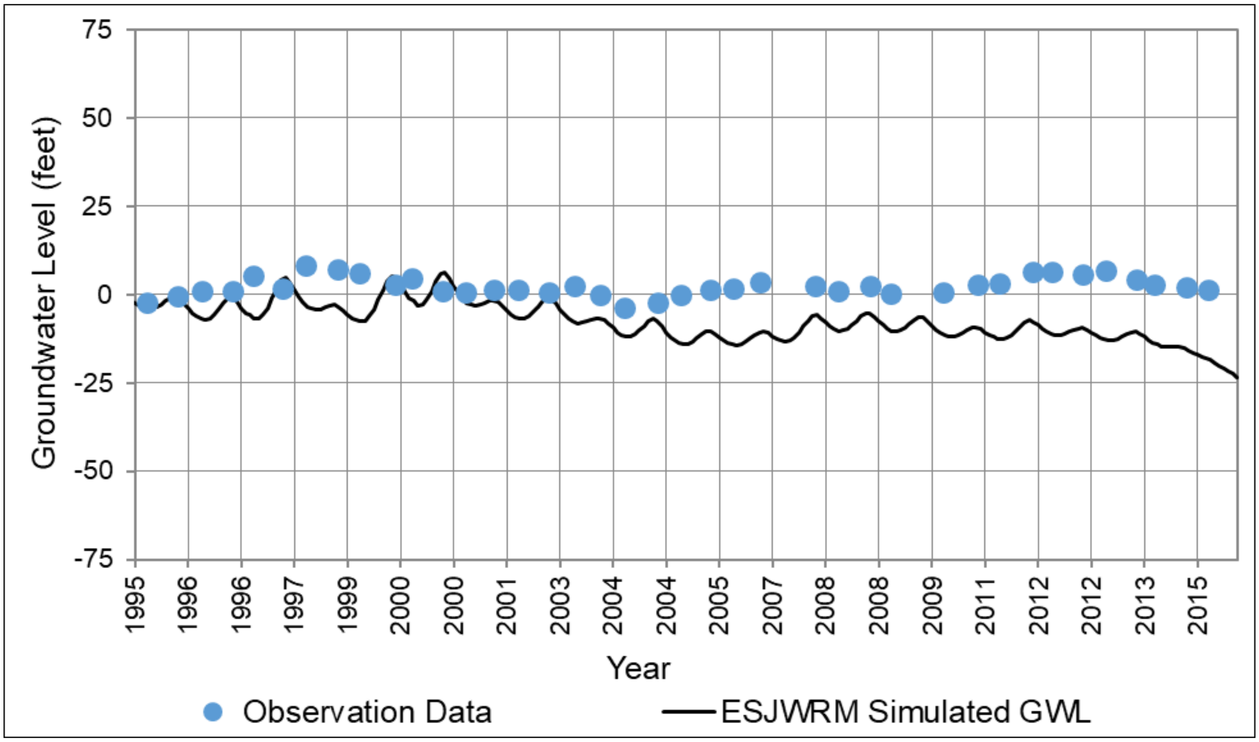


Figure C-43: ESJWRM Groundwater Level Hydrograph – Calibration Well #42

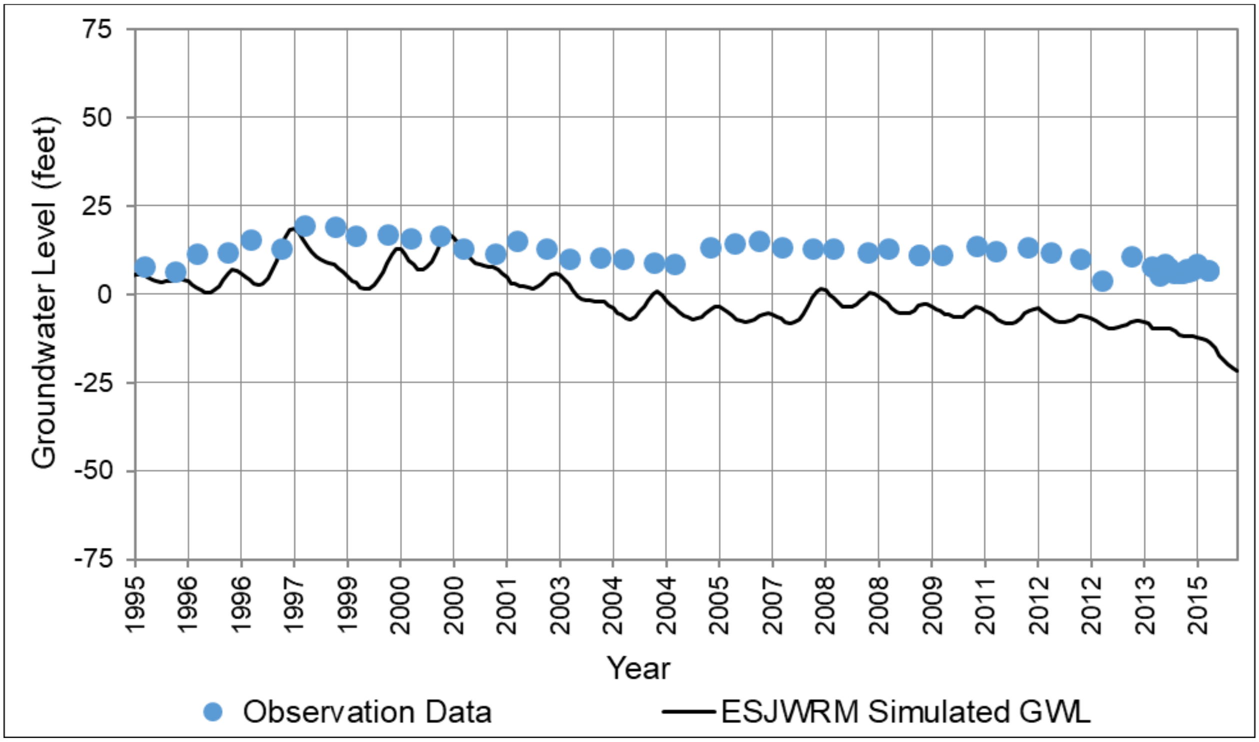


Figure C-44: ESJWRM Groundwater Level Hydrograph – Calibration Well #43

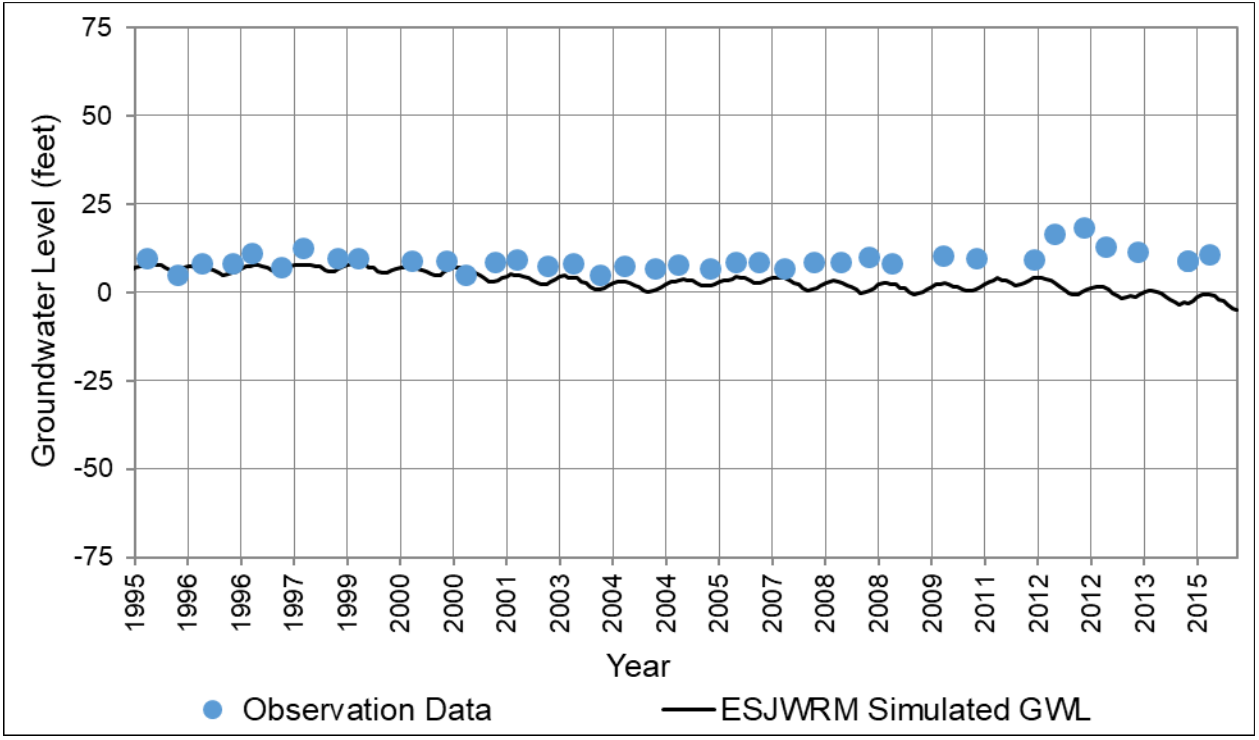


Figure C-45: ESJWRM Groundwater Level Hydrograph – Calibration Well #44

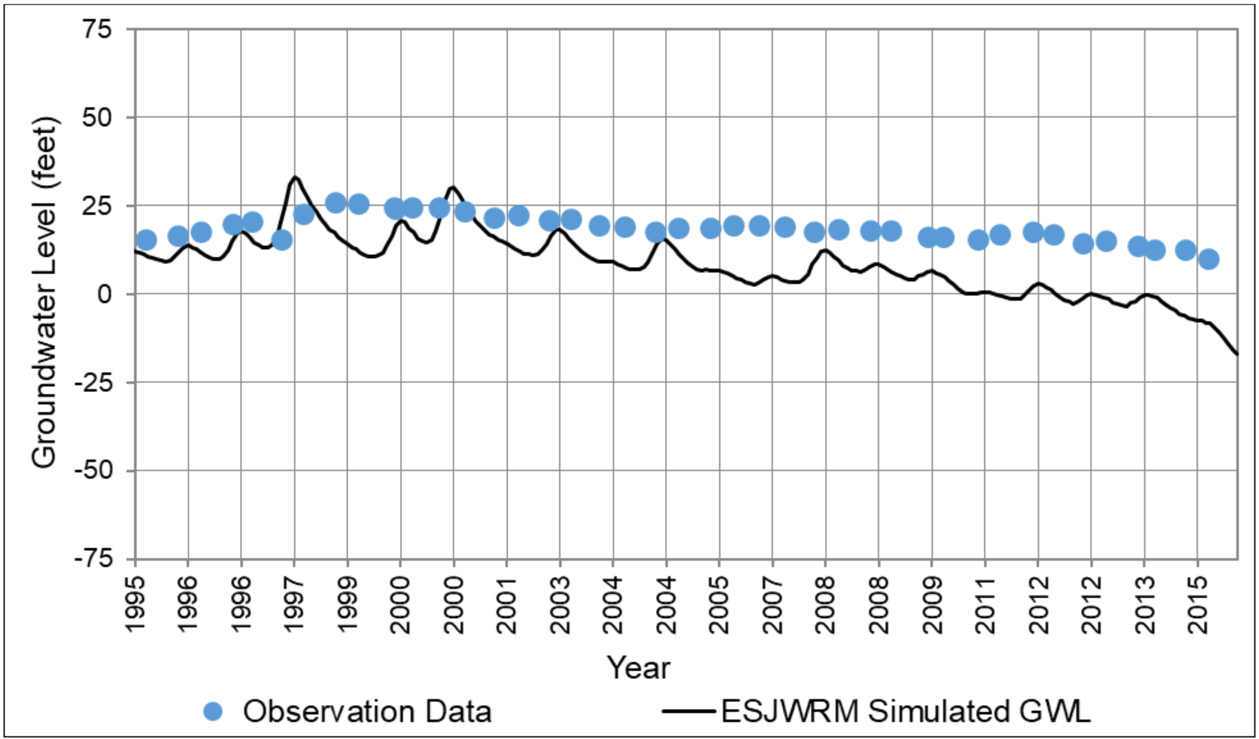


Figure C-46: ESJWRM Groundwater Level Hydrograph – Calibration Well #45

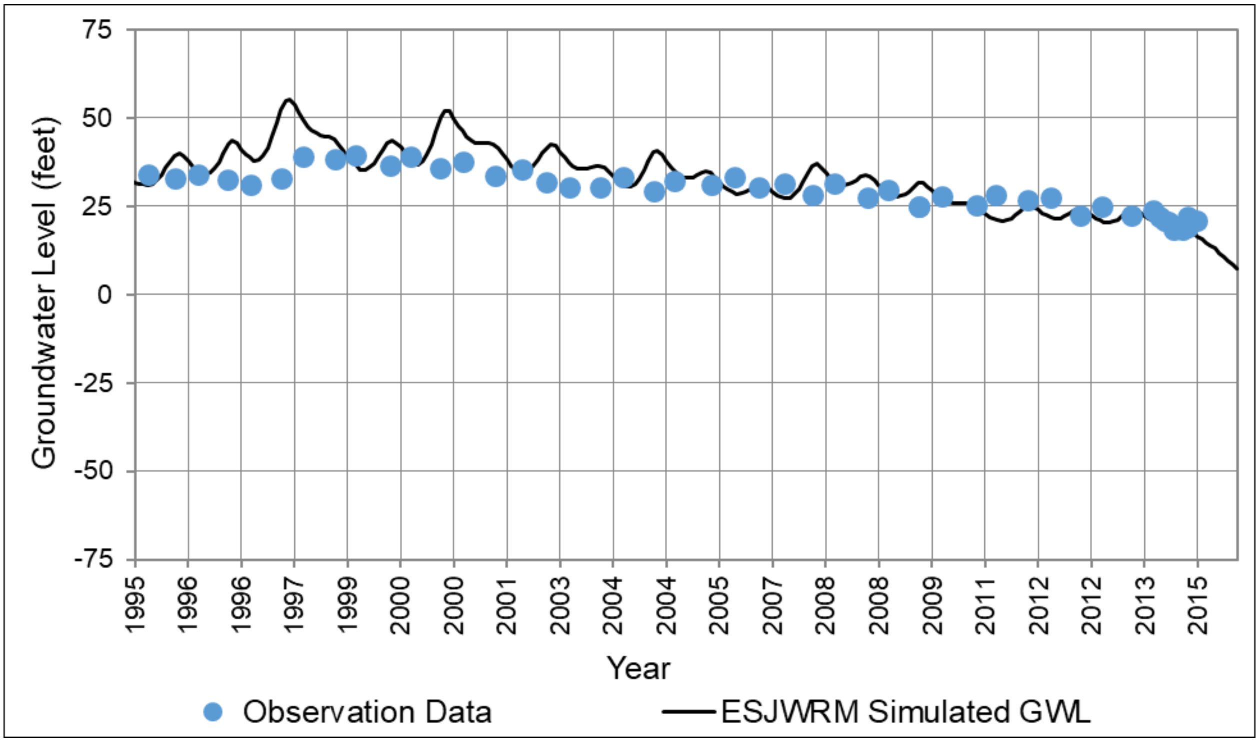


Figure C-47: ESJWRM Groundwater Level Hydrograph – Calibration Well #46

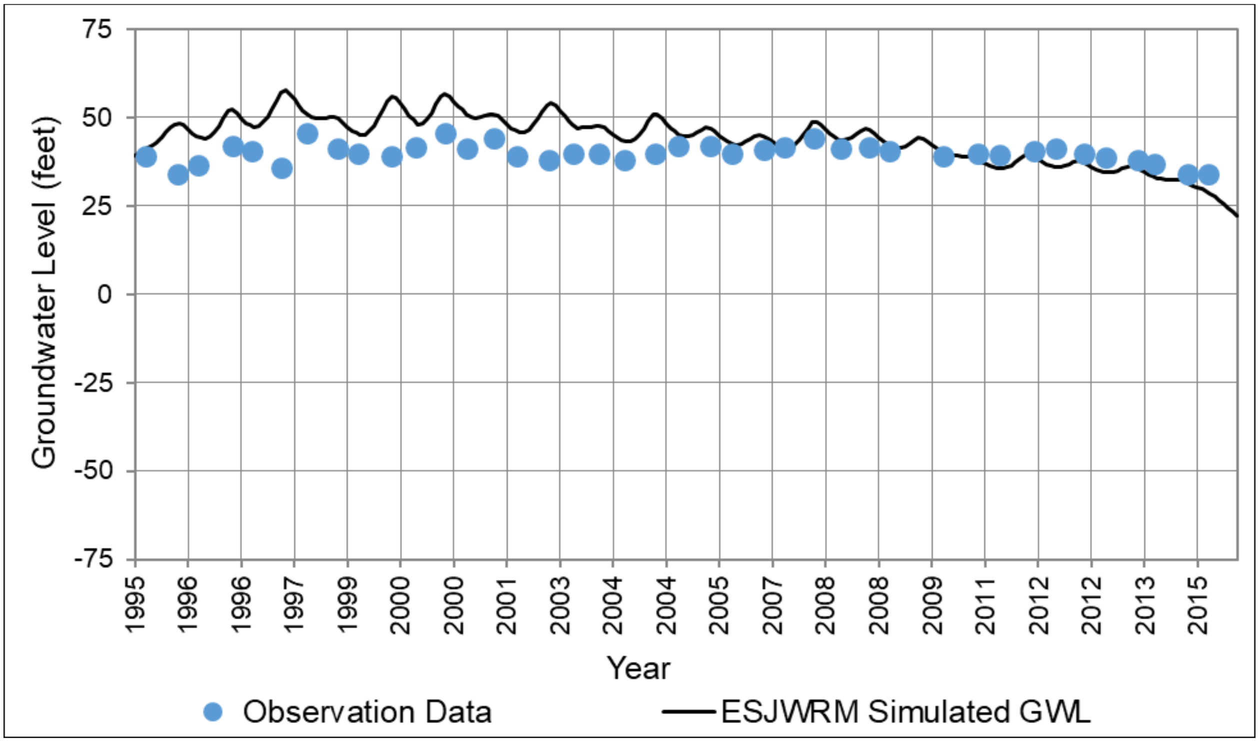


Figure C-48: ESJWRM Groundwater Level Hydrograph – Calibration Well #47

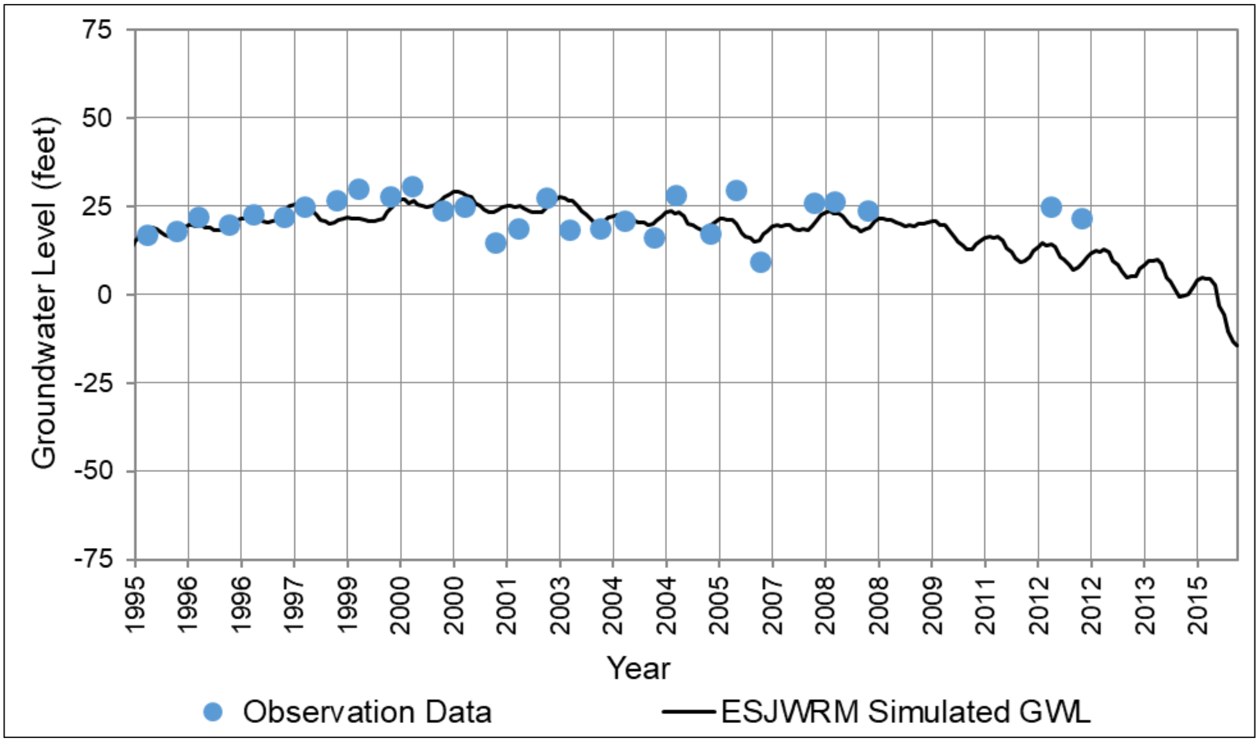


Figure C-49: ESJWRM Groundwater Level Hydrograph – Calibration Well #48

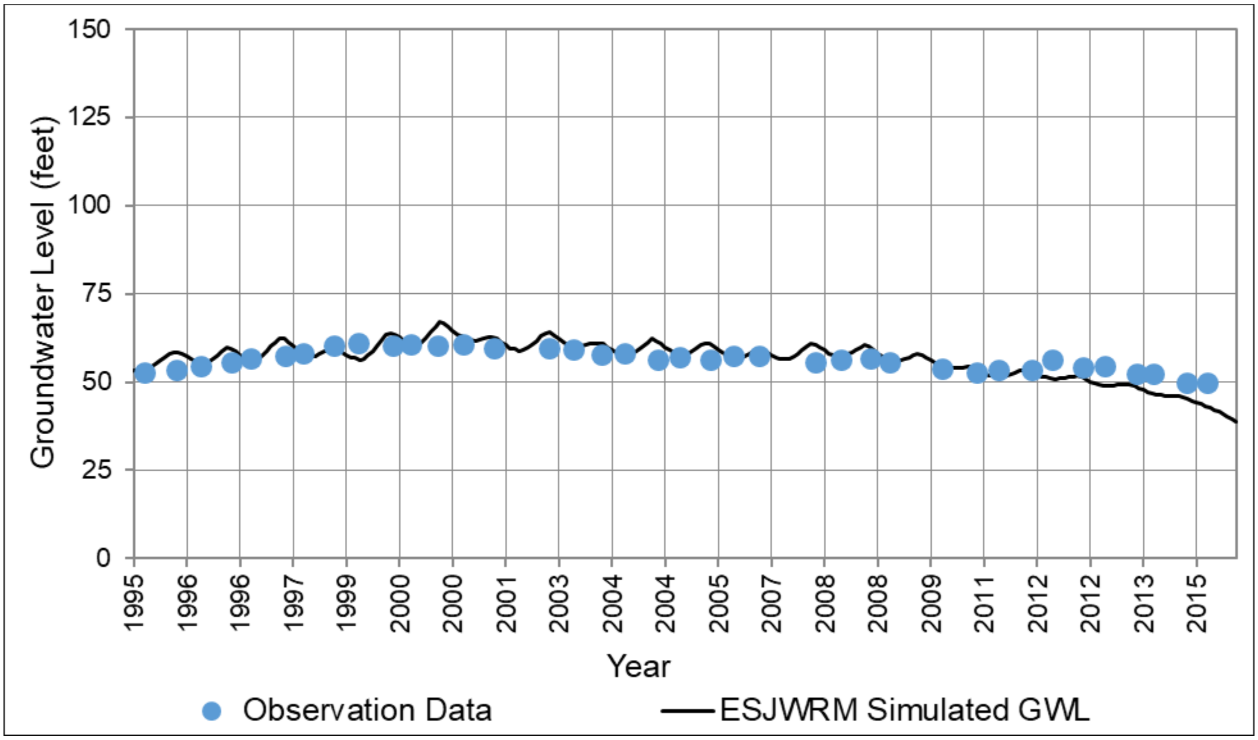


Figure C-50: ESJWRM Groundwater Level Hydrograph – Calibration Well #49

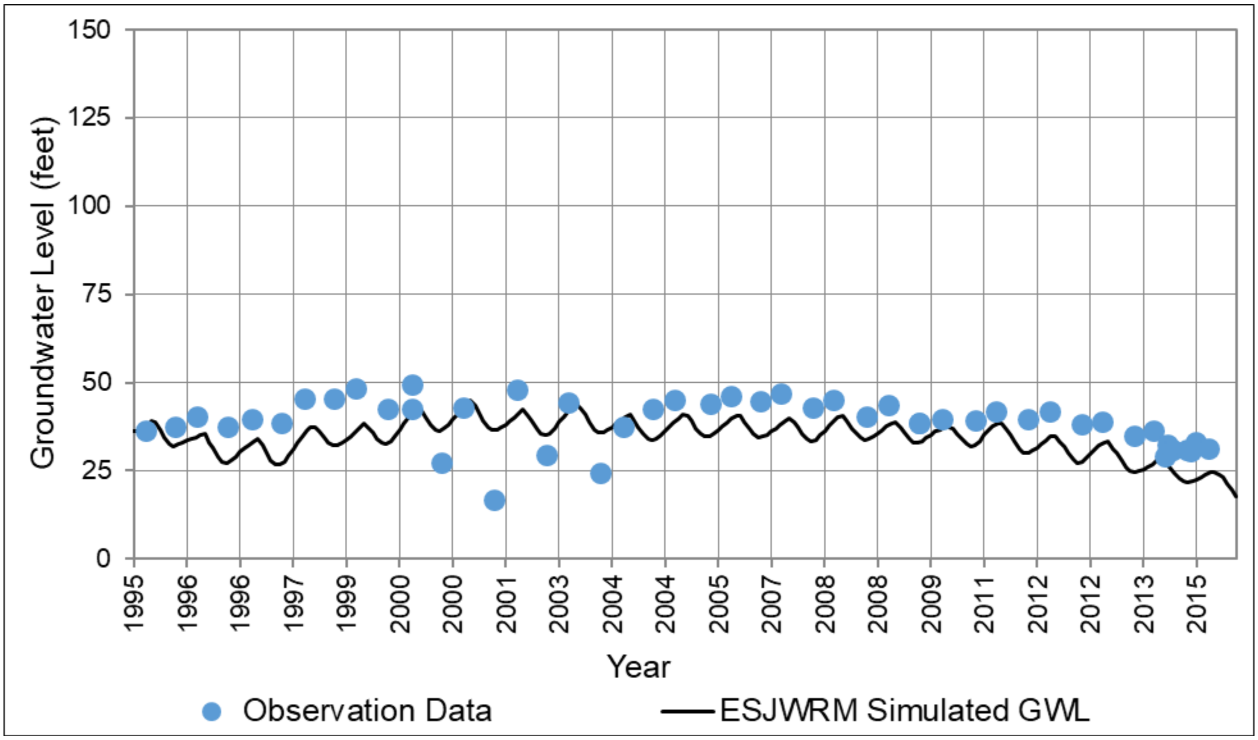


Figure C-51: ESJWRM Groundwater Level Hydrograph – Calibration Well #50

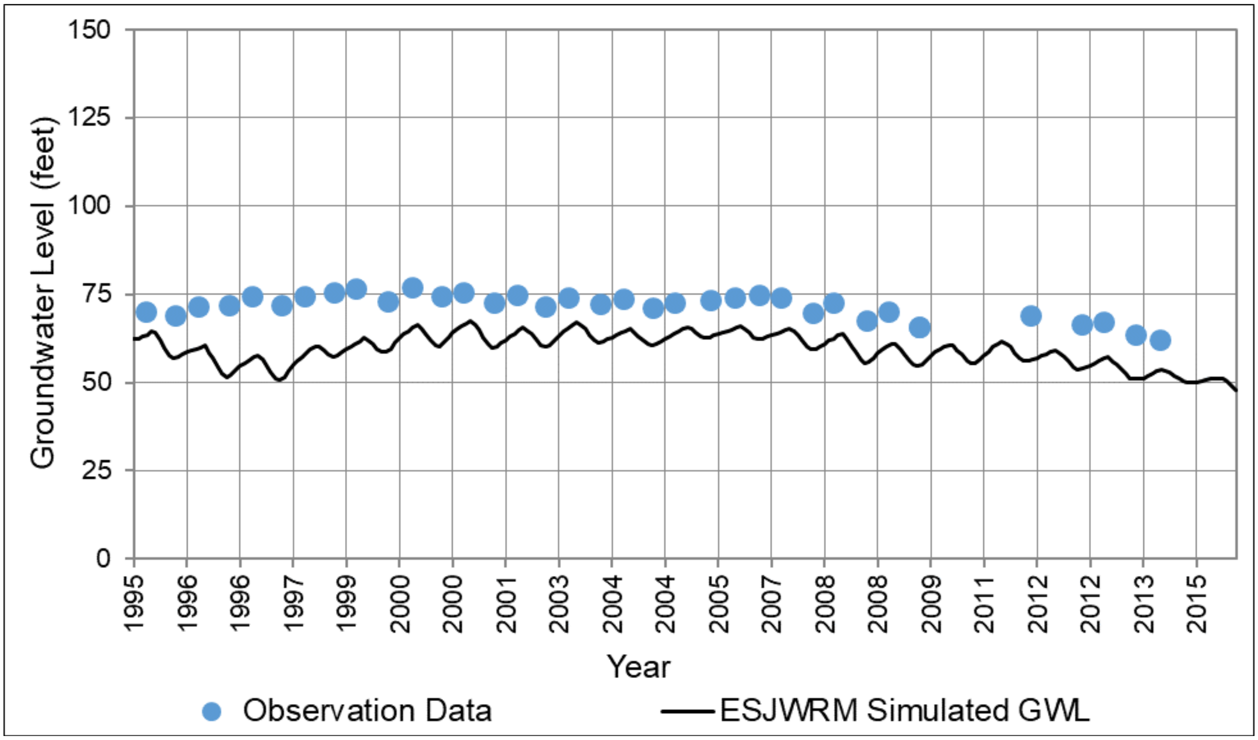


Figure C-52: ESJWRM Groundwater Level Hydrograph – Calibration Well #51

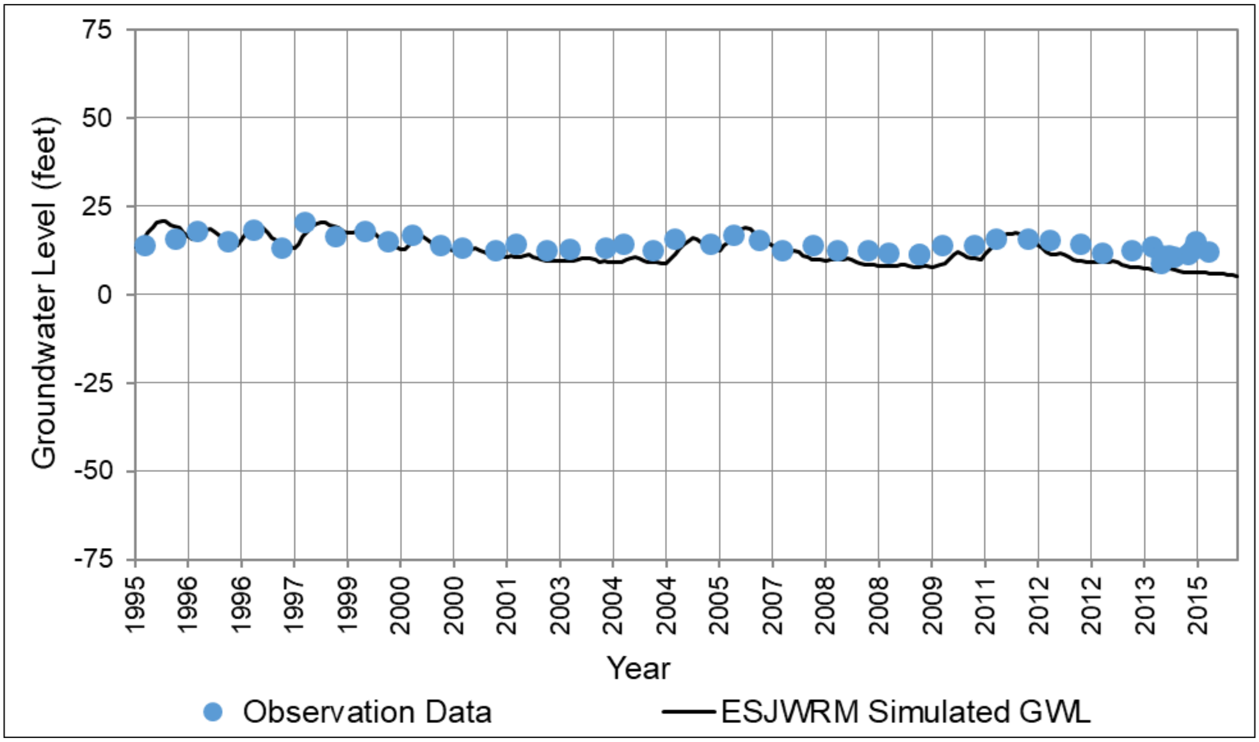


Figure C-53: ESJWRM Groundwater Level Hydrograph – Calibration Well #52

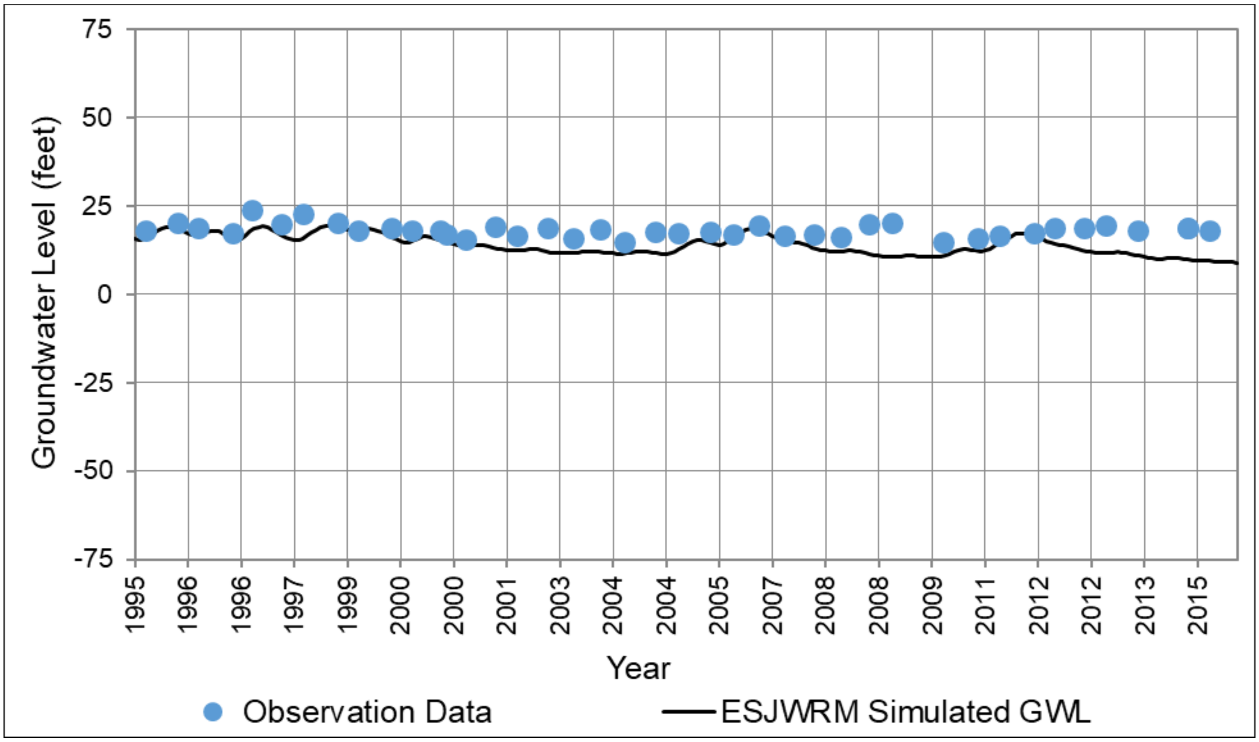


Figure C-54: ESJWRM Groundwater Level Hydrograph – Calibration Well #53

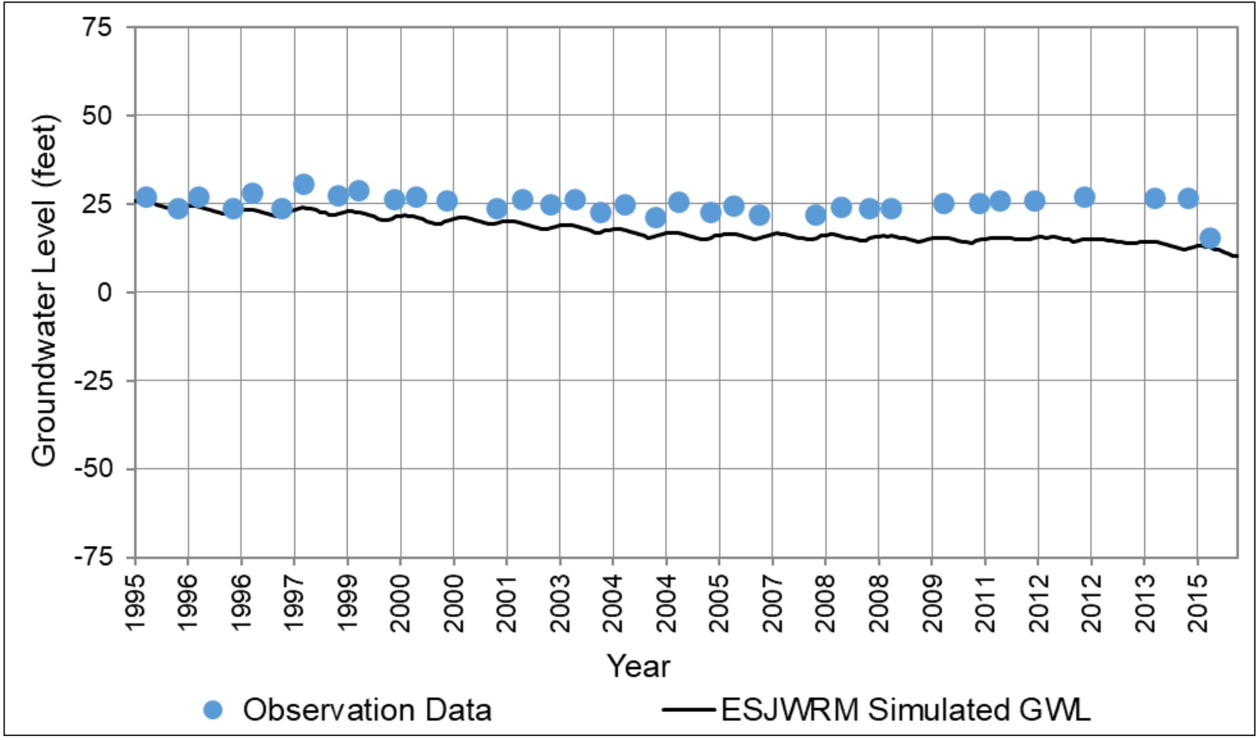


Figure C-55: ESJWRM Groundwater Level Hydrograph – Calibration Well #54

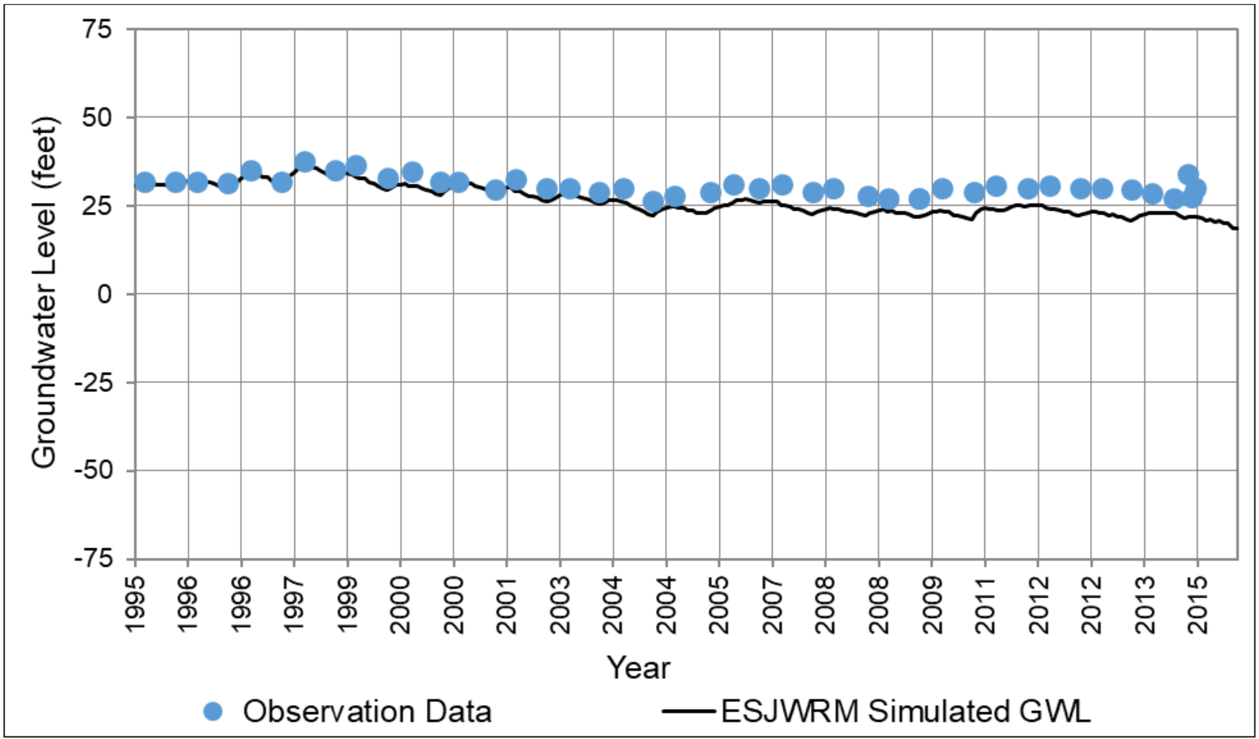


Figure C-56: ESJWRM Groundwater Level Hydrograph – Calibration Well #55

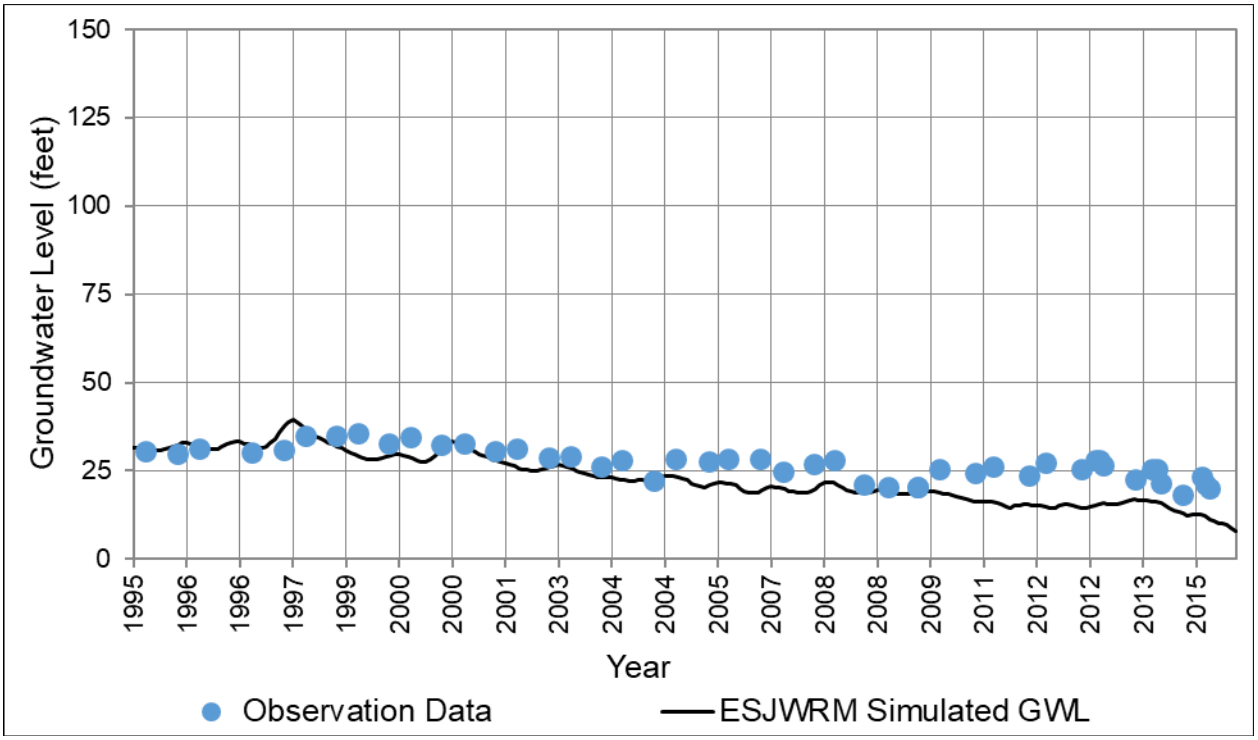


Figure C-57: ESJWRM Groundwater Level Hydrograph – Calibration Well #56

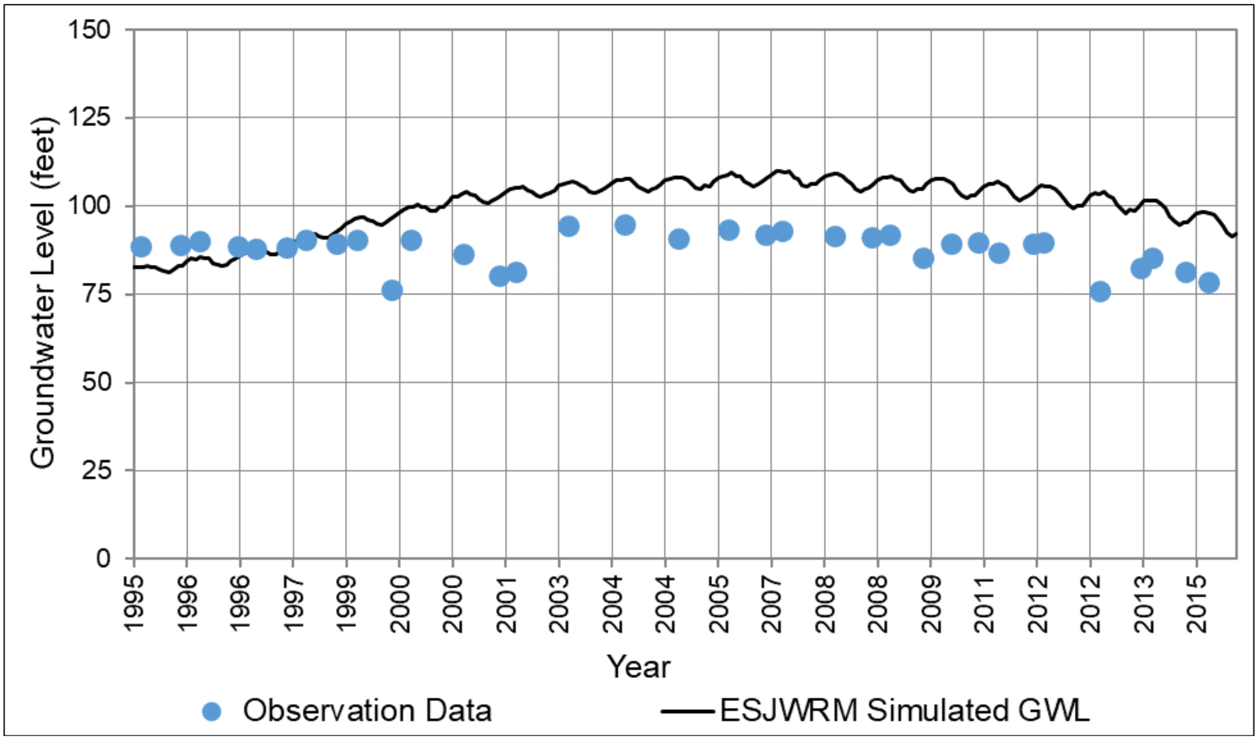


Figure C-58: ESJWRM Groundwater Level Hydrograph – Calibration Well #57

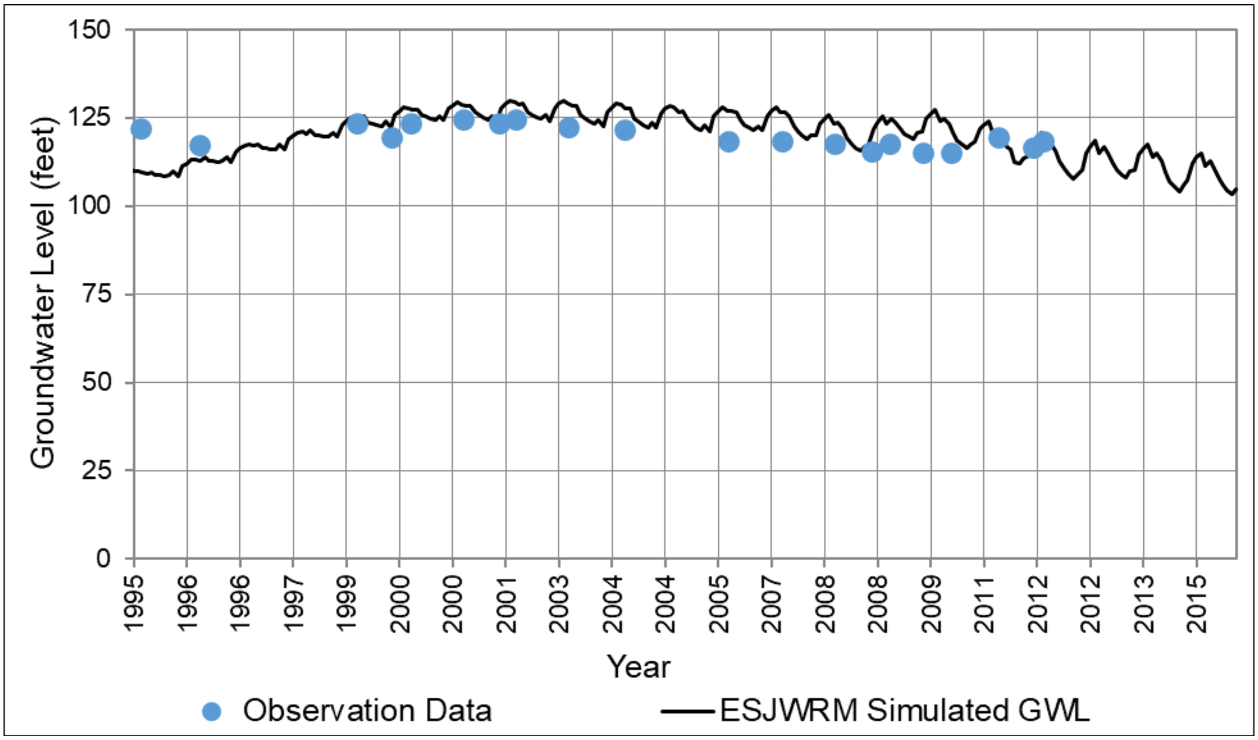


Figure C-59: ESJWRM Groundwater Level Hydrograph – Calibration Well #58

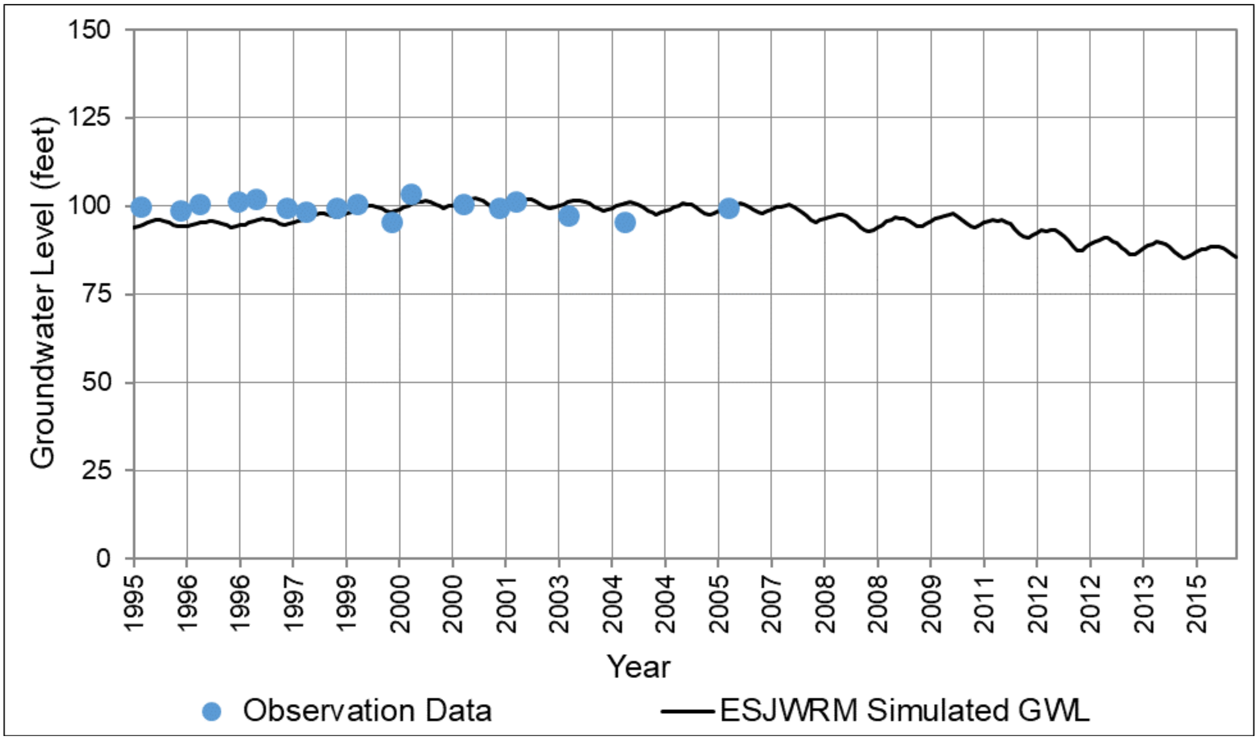


Figure C-60: ESJWRM Groundwater Level Hydrograph – Calibration Well #59

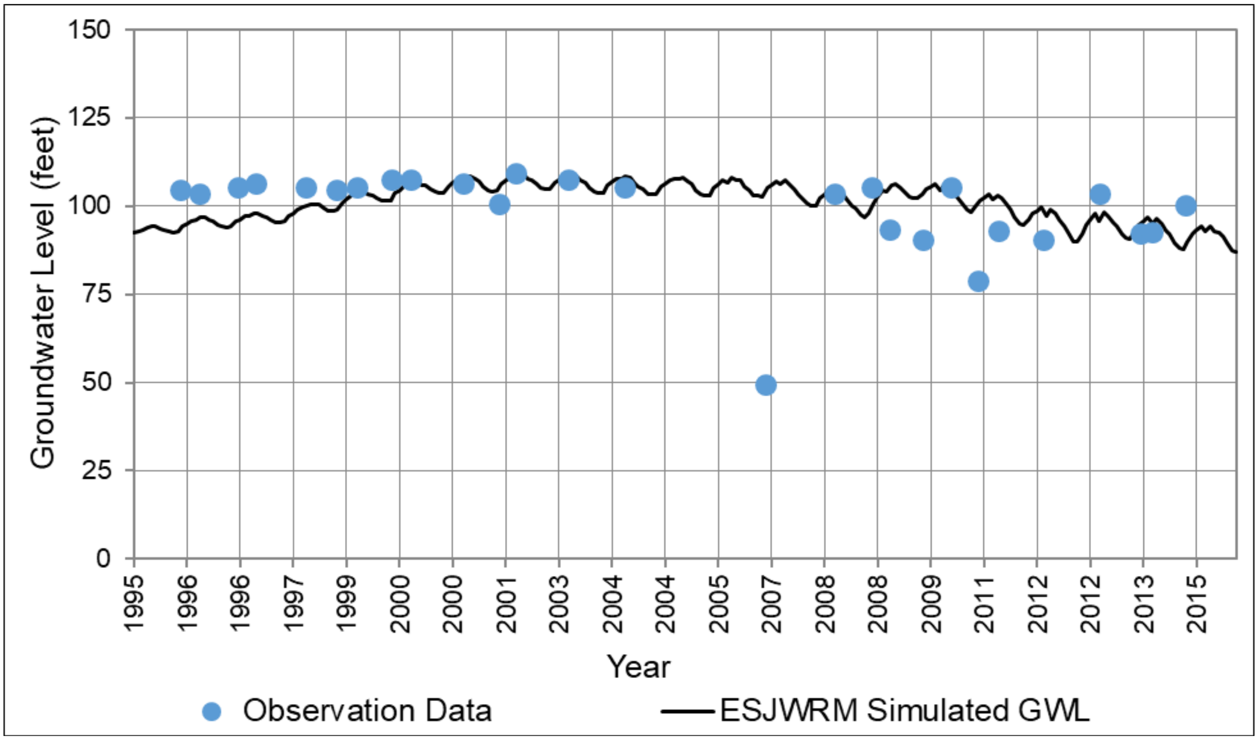


Figure C-61: ESJWRM Groundwater Level Hydrograph – Calibration Well #60

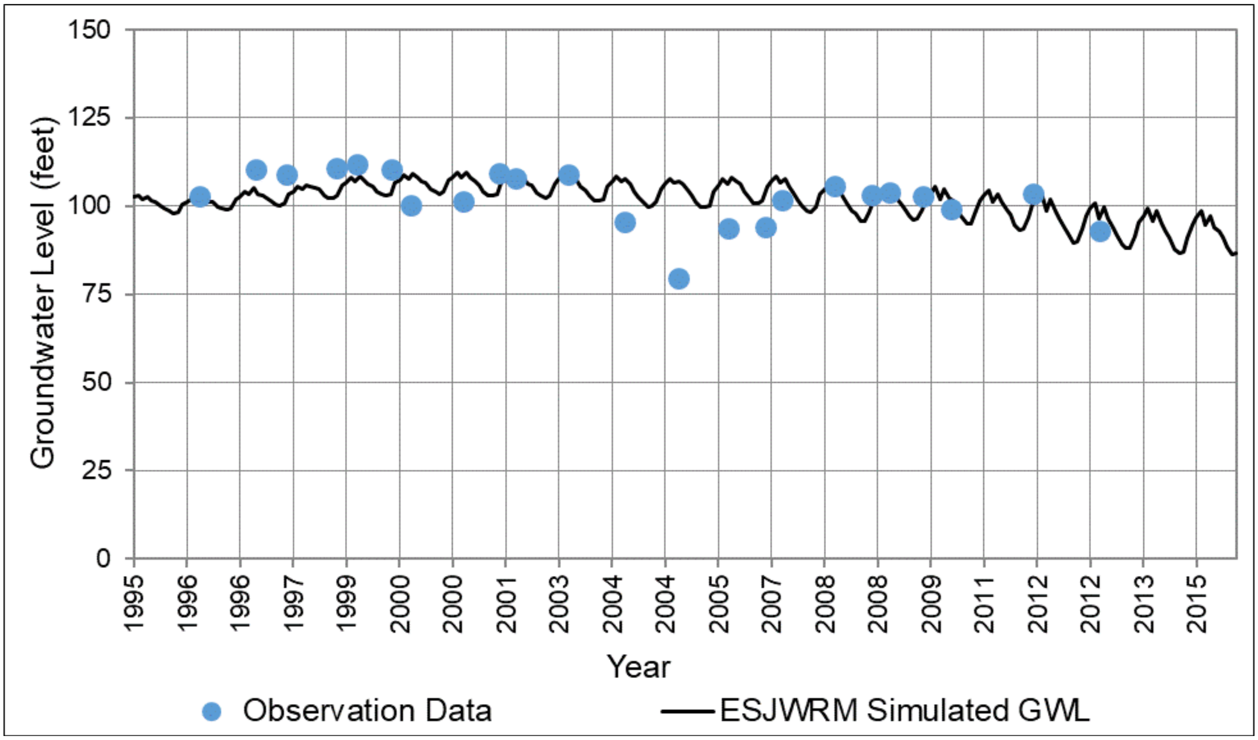


Figure C-62: ESJWRM Groundwater Level Hydrograph – Calibration Well #61

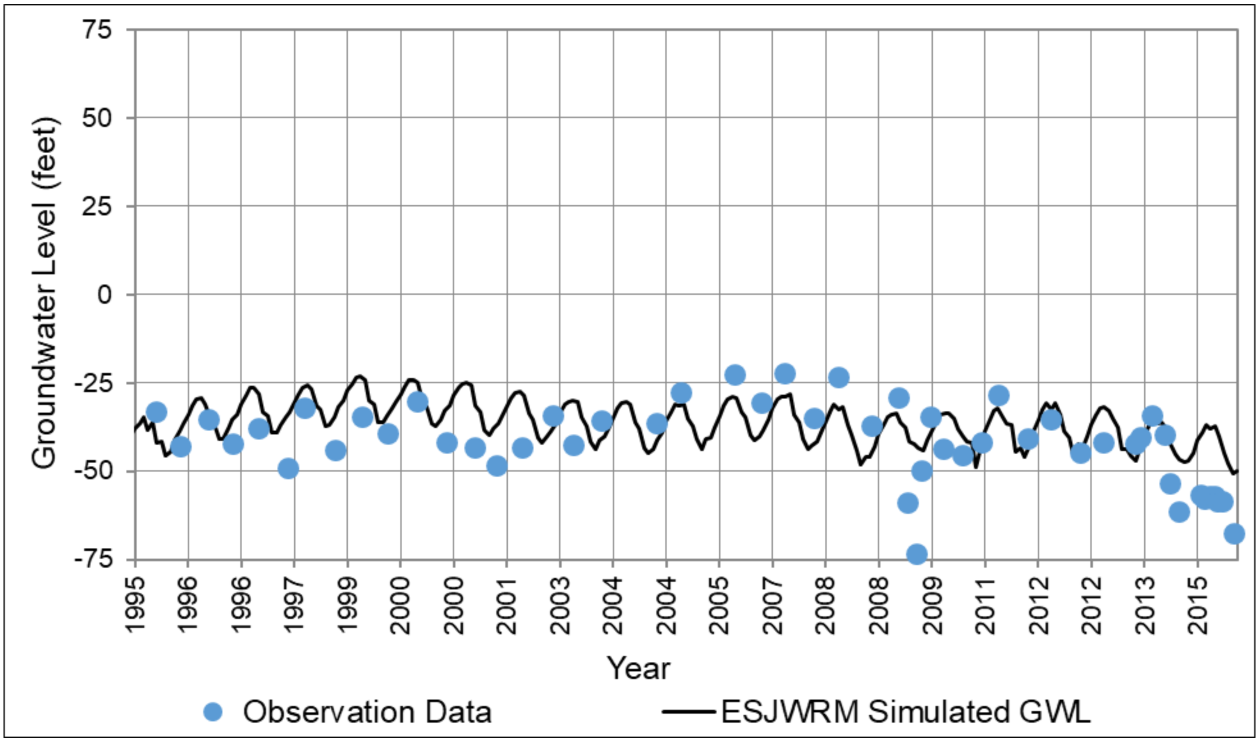


Figure C-63: ESJWRM Groundwater Level Hydrograph – Calibration Well #62

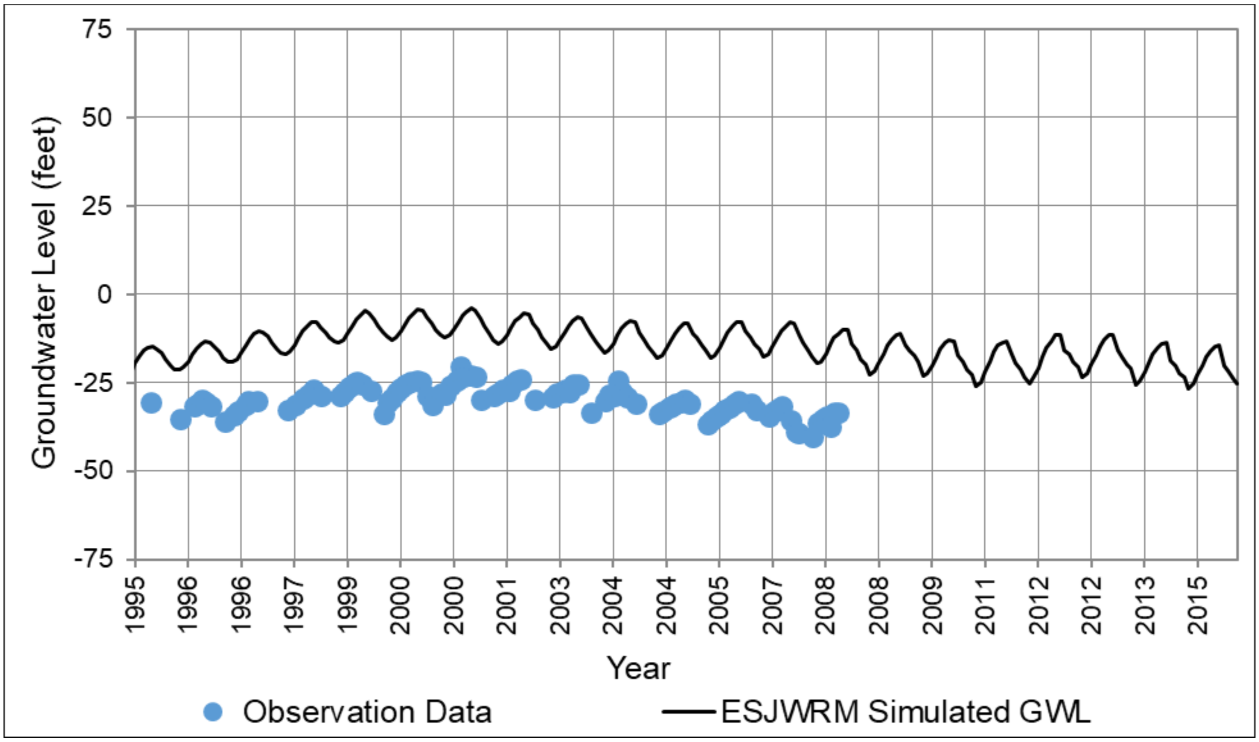


Figure C-64: ESJWRM Groundwater Level Hydrograph – Calibration Well #63

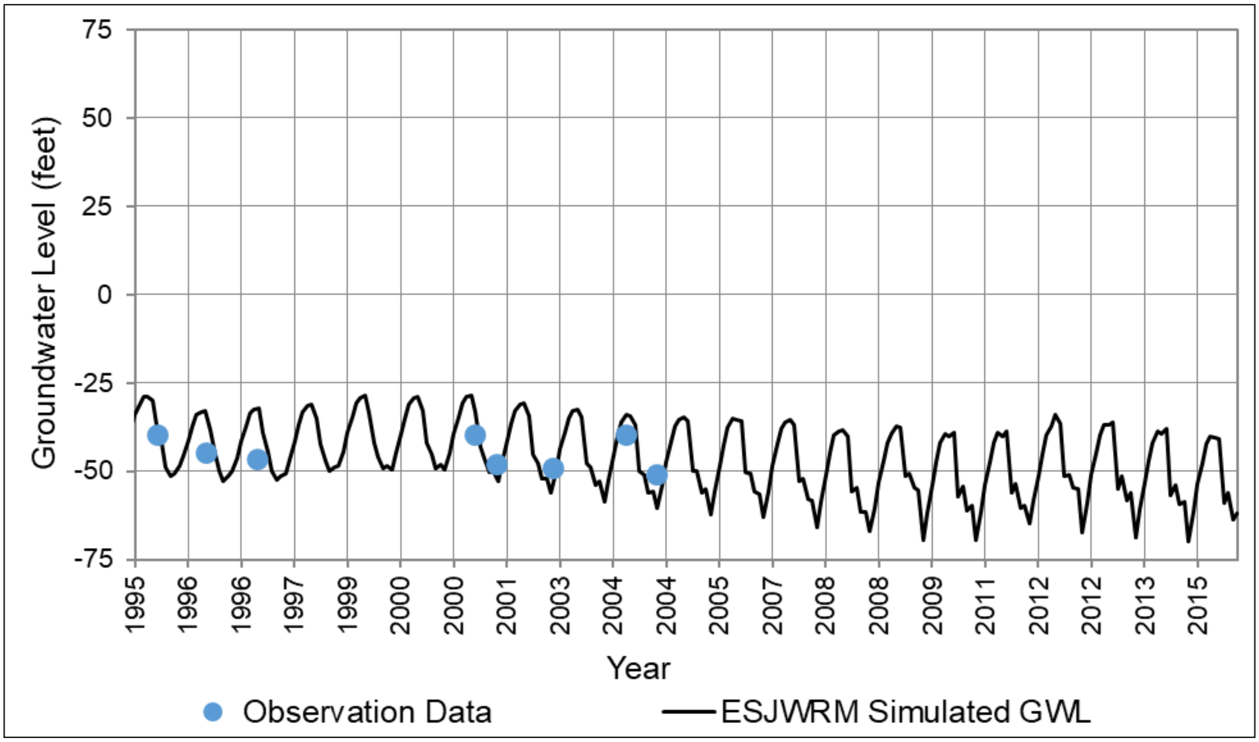


Figure C-65: ESJWRM Groundwater Level Hydrograph – Calibration Well #64

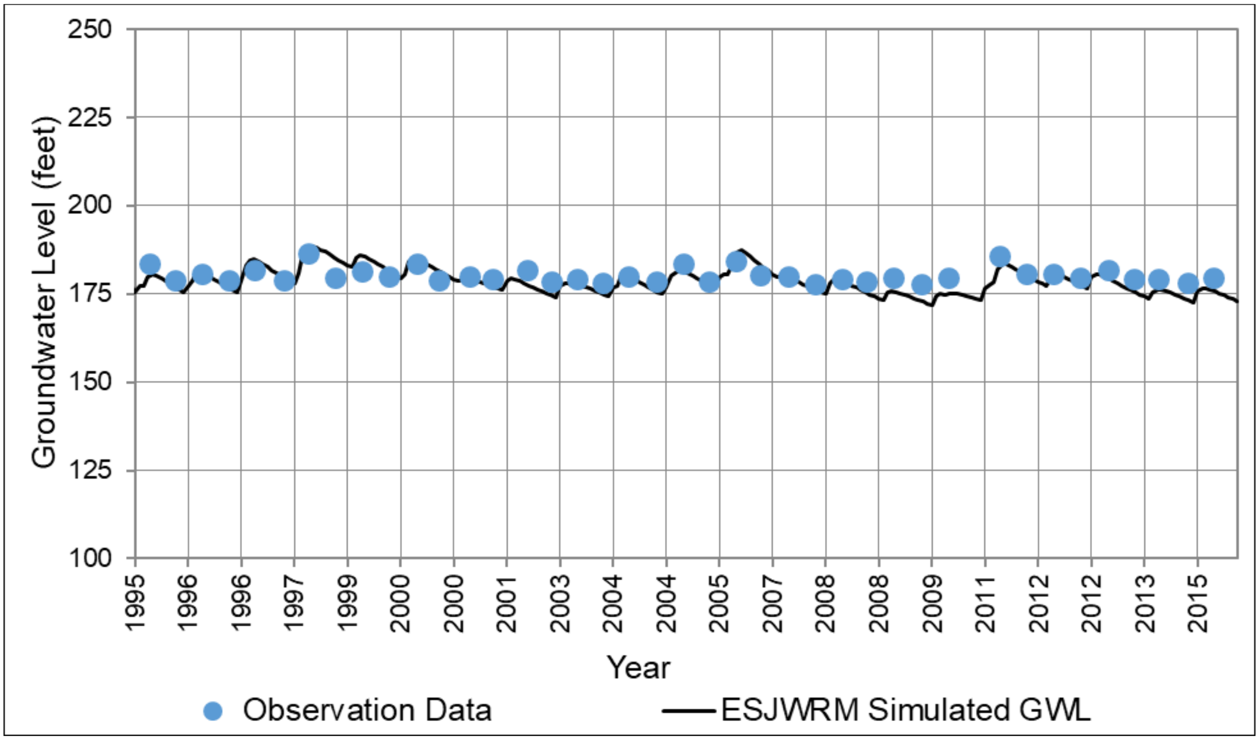


Figure C-66: ESJWRM Groundwater Level Hydrograph – Calibration Well #65

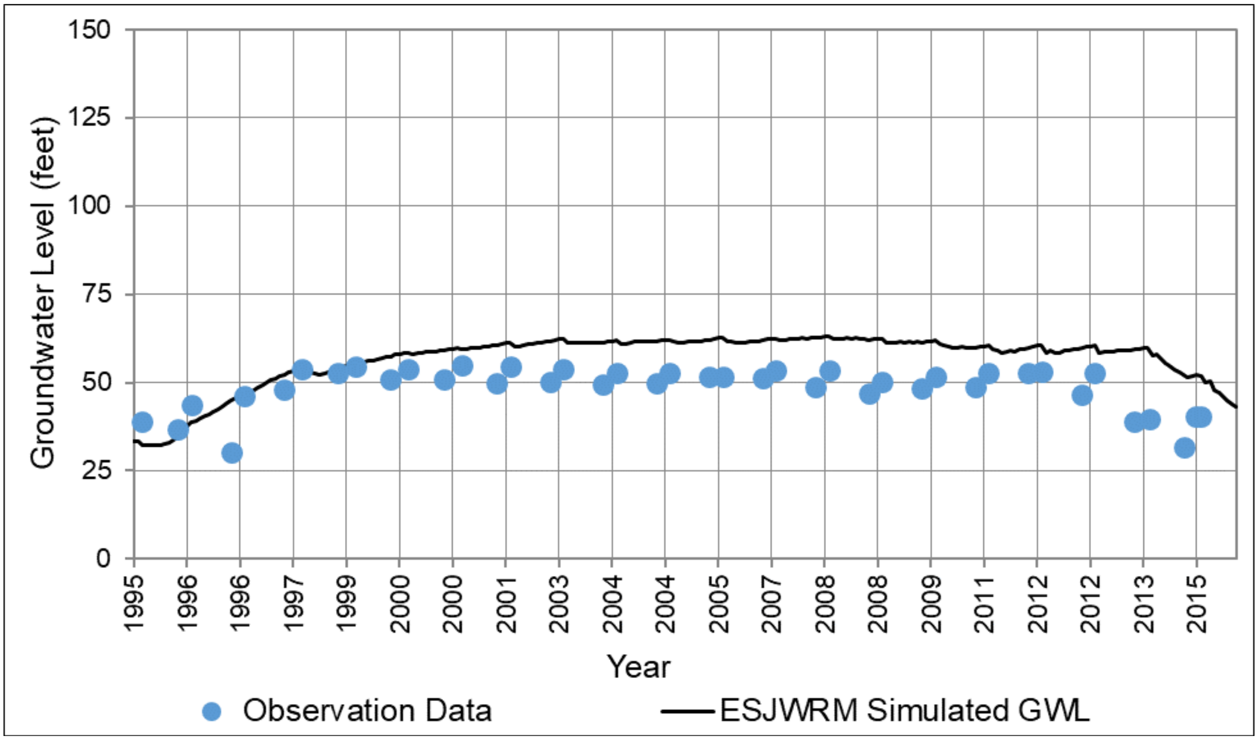


Figure C-67: ESJWRM Groundwater Level Hydrograph – Calibration Well #66

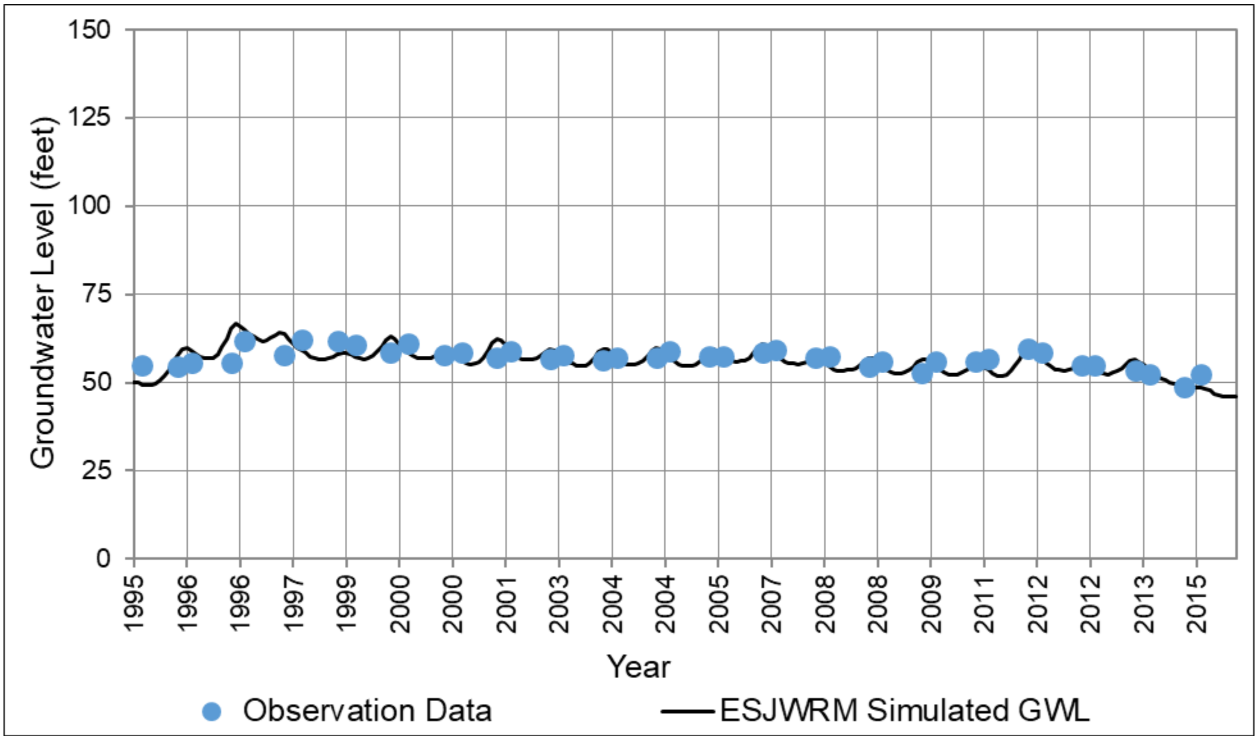


Figure C-68: ESJWRM Groundwater Level Hydrograph – Calibration Well #67

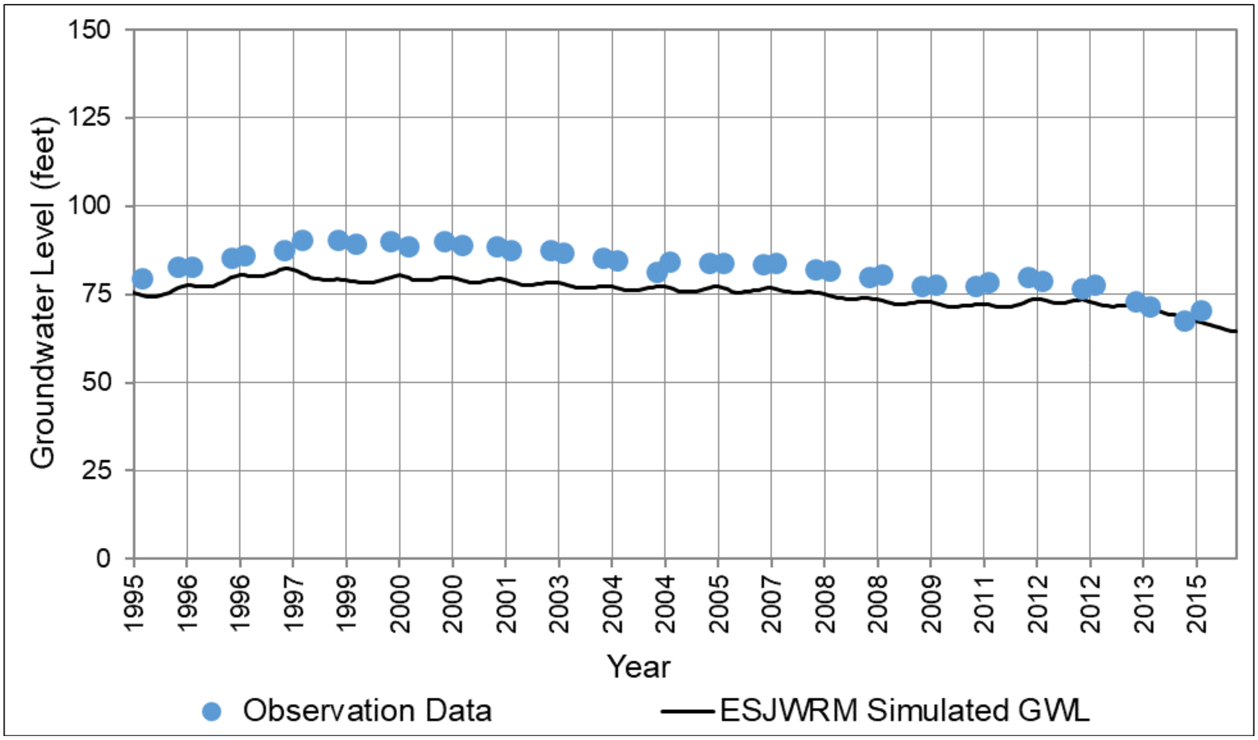


Figure C-69: ESJWRM Groundwater Level Hydrograph – Calibration Well #68

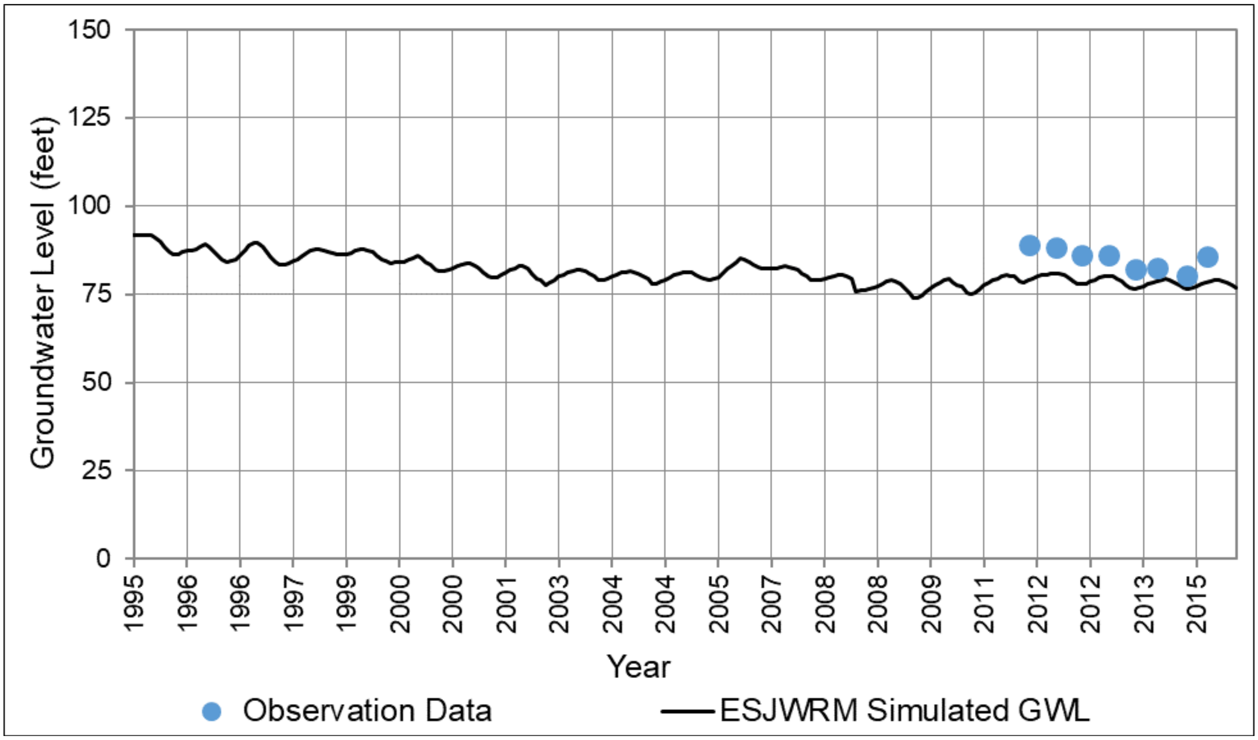


Figure C-70: ESJWRM Groundwater Level Hydrograph – Calibration Well #69

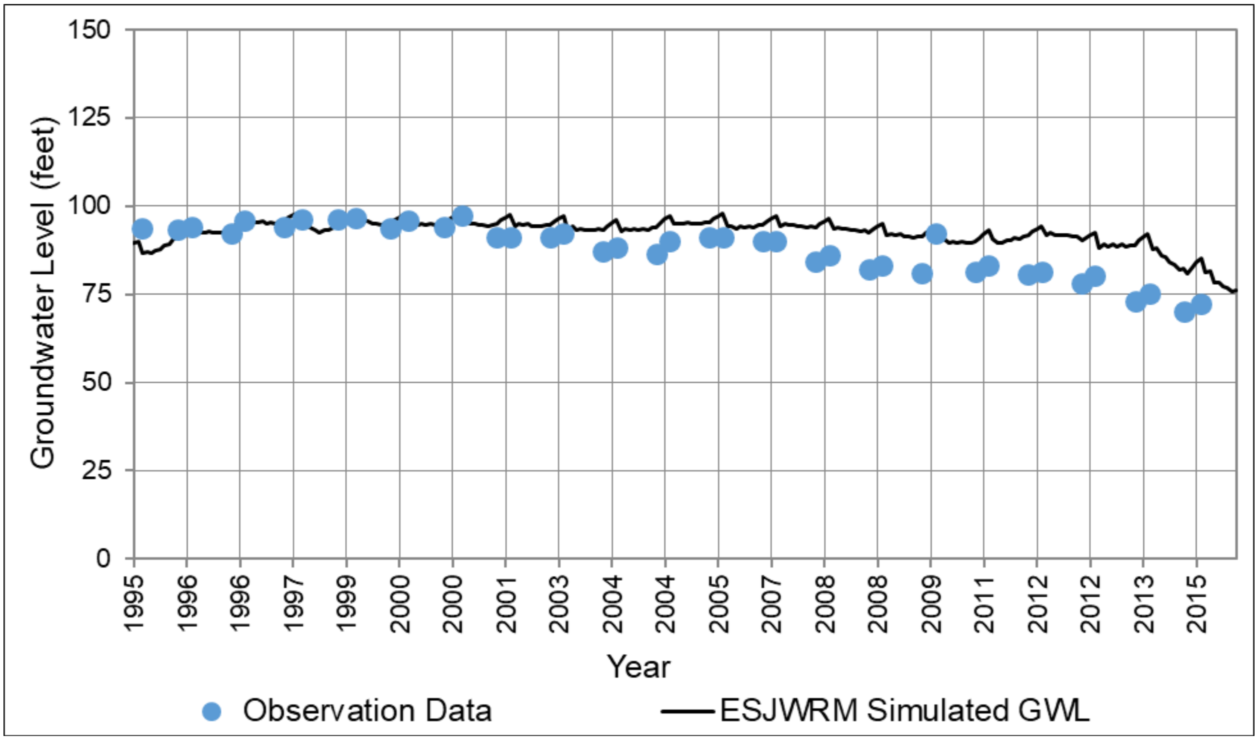
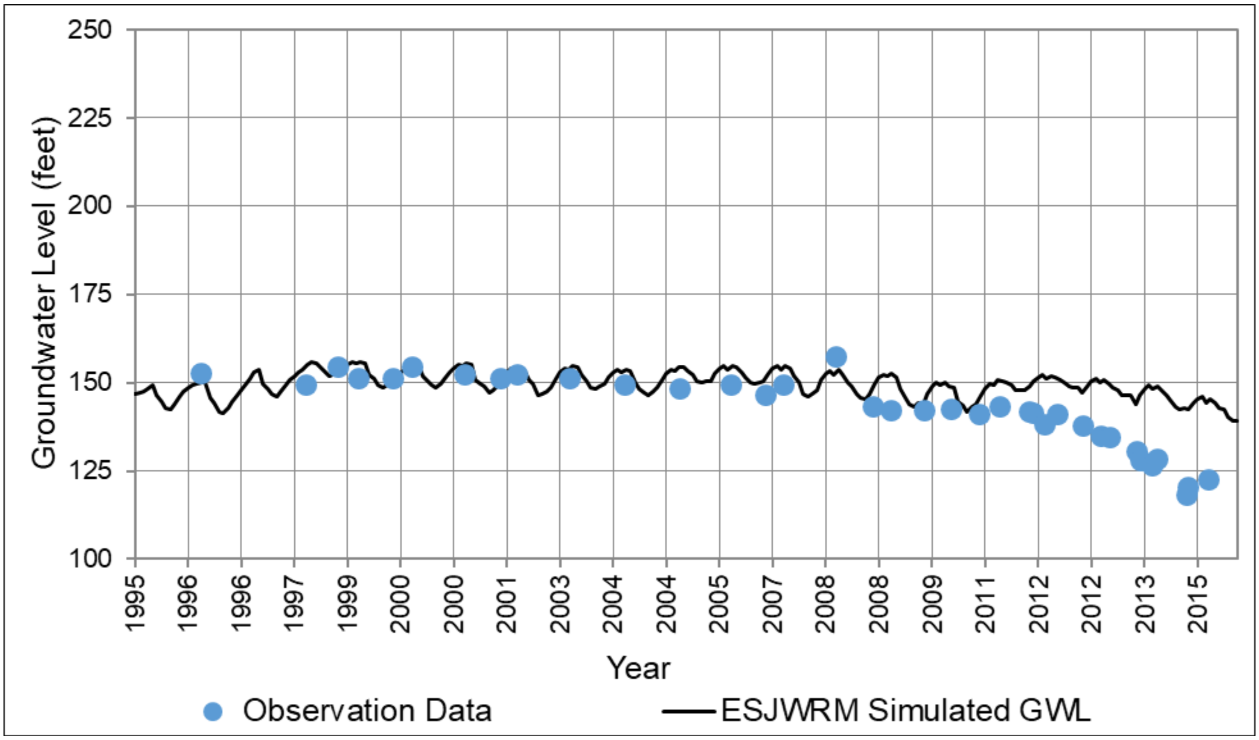


Figure C-71: ESJWRM Groundwater Level Hydrograph – Calibration Well #70



This page is intentionally left blank.

APPENDIX 2-B.
TECHNICAL MEMORANDUM NO. 1 – UNDESIRABLE RESULT DEFINITION AND PROJECTS AND MANAGEMENT ACTIONS

TECHNICAL MEMORANDUM NO. 1 – Undesirable Result Definition and Projects and Management Actions

TO:	Paul Gosselin, California Department of Water Resources Deputy Director
CC:	Matt Zidar, on behalf of the Eastern San Joaquin Groundwater Authority
PREPARED BY:	Leslie Dumas, Sara Miller, and Lindsay Martien/Woodard & Curran
DATE:	June 24, 2022
RE:	Eastern San Joaquin Groundwater Authority Response to DWR's November 18, 2021 Consultation Initiation Letter - Technical Memorandum 1, Response to DWR Deficiency No. 1 and Corrective Actions 1(a)-1(c)

---

1. Introduction

The Eastern San Joaquin Groundwater Authority (ESJGWA) received a Consultation Initiation Letter (Letter) on November 18, 2021 (**Attachment 1**), from the California Department of Water Resources (DWR). The Letter identified two potential deficiencies with the Eastern San Joaquin Groundwater Subbasin (Subbasin) Groundwater Sustainability Plan (GSP) which may preclude DWR's approval, as well as potential corrective actions to address each potential deficiency. The Letter thus initiated consultation between DWR, the Plan Manager, and the Subbasin's groundwater sustainability agencies (GSAs) regarding the amount of time needed to address the potential deficiencies and corrective actions. A subsequent meeting with DWR was held on April 4, 2022 to discuss the Subbasin's proposed approach to addressing the identified deficiencies. The analysis presented in this memorandum was completed in response to the Letter, based on direction provided by the ESJGWA, the Subbasin GSAs, and DWR. It is intended to supplement the Eastern San Joaquin GSP that was submitted in January 2020 and fill potential gaps identified in the Letter provided by DWR.

The following sections provide a response to **Potential Corrective Actions 1(a) and 1(b)**, identified under **Potential Deficiency 1**. Per discussion with DWR staff, in adequately addressing Potential Corrective Action 1(a) and 1(b), **Potential Corrective Action 1(c)** is no longer applicable and will not need to be addressed by the GSAs.

Potential Deficiency 1

Potential Deficiency 1 relates to the GSP's requirement of two consecutive non-dry (i.e., below normal, above normal, or wet) water year types and the exclusion of dry and critically dry water-year types in the identification of undesirable results. It also requests additional detail on how projects and management actions, in conjunction with the proposed chronic lowering of groundwater levels sustainable management criteria, will offset drought related groundwater reductions and avoid significant and unreasonable impacts.

Potential Corrective Action 1 contains six subparts, 1(a) through 1(f). Potential Corrective Actions 1(a) and 1(b), the focus of this memorandum, are summarized below. As stated above, Potential Corrective Action 1(c) is no longer applicable once 1(a) and 1(b) are addressed. Potential Corrective Actions 1(d) through 1(f) are addressed in separate technical memoranda.

- **Potential Corrective Action 1(a):** The Letter states that DWR staff find the water year type requirement in the definition for undesirable results for groundwater levels (i.e., two consecutive *non-dry* years) to be "inconsistent with the objectives of SGMA", and that this requirement could potentially allow for "unmanaged and continued lowering of groundwater levels under certain hydraulic and climatic conditions that have occurred historically". As a Potential Corrective Action, the following is suggested: "The GSAs should remove the water year type requirement from the GSP's undesirable result definition."

- **Potential Corrective Action 1(b):** The second part of this Potential Corrective Action seeks additional detail on how projects and management actions will offset drought-related groundwater reductions and avoid significant and unreasonable impacts. The Letter states that the GSP "fails to identify specific extraction and groundwater recharge management actions the GSAs would implement or otherwise describe how the Subbasin would be managed to offset...dry year reductions of groundwater storage". As a Potential Corrective Action, the following is suggested: "The GSP should be revised to include specific projects and management actions the GSAs would implement to offset drought year groundwater level declines."

The following sections provide a response to Potential Corrective Actions 1(a) and 1(b) and include a discussion of updated modeling work related to both Potential Corrective Actions. The purpose of this new analysis is to provide supplemental information, justification, and data needed to support the GSP and address each issue identified.

2. Removal of Water Year Type Requirement

In response to the comments provided by DWR in Potential Corrective Action 1(a), the ESJGWA has removed the non-dry water year type requirement from the definition of undesirable results for chronic lowering of groundwater levels, and, by proxy, for reduction of groundwater storage, land subsidence, and depletions of interconnected surface water. An updated redline strike out version of the GSP has been developed and adopted by the GSAs in response to this review. Relevant updated text is provided below.

> **Section 3.2.1.1.2. Identification of Undesirable Results (Chronic Lowering of Groundwater Levels)**
>
> *An undesirable result is considered to occur during GSP implementation when at least 25 percent of representative monitoring wells used to monitor groundwater levels (5 of 20 wells in the Subbasin) fall below their minimum level thresholds for two consecutive years* ~~*that are categorized as non-dry years (below-normal, above-normal, or wet), according to the San Joaquin Valley Water Year Hydrologic Classification. The lowering of groundwater levels during consecutive dry or critically-dry years is not considered to be unreasonable,*~~

> ~~and would therefore not be considered an undesirable result, unless the levels do not rebound to above the thresholds following those consecutive non-dry years~~.

Additional modeling, described in the sections below, demonstrates that the Subbasin is not projected to be in violation of its minimum thresholds with this updated definition of undesirable results once planned projects and management actions are in place.

3. Project and Management Actions Assumptions

As part of the process to respond to DWR, the ESJGWA worked with each GSA individually to update GSP project descriptions with new information that has become available in the past two years since the GSP was first adopted in 2020. These revised projects were divided into two categories: Category A projects (projects that are likely to advance in the next five years and have existing water rights or agreements) and Category B projects (projects that are not anticipated to advance in the next five years, but could be leveraged in the future, particularly if Category A projects do not fully achieve stated recharge and/or offset targets). Category B projects may be elevated to a Category A project should feasibility studies demonstrate a viable project, if water rights or contracts are firmly identified, if partnerships are formed, and if economic evaluation demonstrate that the projects are cost effective.

The analysis presented in this TM focuses on the simulation of implementation of Category A projects, which includes in lieu and direct recharge projects. **Table 1** provides a list of these Category A projects, submitting GSA, project type, water source, and volume anticipated in each water year type. **Table 2** provides a list of Category B projects for reference. Additional details, including water year type descriptions and updated project descriptions, assumptions, and Subbasin model results, can be found in **Attachment 2**.

In total, 11 Category A projects have been identified. Six are in-lieu recharge projects, three are direct recharge projects, and two are a combination of in-lieu recharge and direct recharge. Overall, the total additional surface water provided by Category A projects (either by in lieu or direct recharge) varies by water year type and ranges from 36,300 to 96,700 acre-feet per year (AFY) and is a mixture of deliveries to agricultural customers (including assumptions on evaporation and delivery losses), deliveries to urban customers, and direct recharge projects. A summary of the total additional water supply (excluding assumed losses) anticipated from Category A projects is below.

- Additional surface water delivered to the Subbasin for agricultural uses: average of 39,700 AFY (range of 9,500-56,300 AFY)
- Additional surface water delivered to the Subbasin for urban uses: 5,000 AFY or 20,000 AFY in only dry and drought years, respectively
- Additional groundwater stored via direct groundwater recharge: average of 21,200 AFY (range of 6,500-32,000 AFY)

Table 1: Category A Projects

Project	Submitting GSA	Project Type	Water Source	Baseline Water Year Type	Annual Volume (AFY)	Notes
1. Lake Grupe In-Lieu Recharge	Stockton East Water District	In-Lieu Recharge	The surface water source of this project is from SEWD's existing contract with the U.S. Bureau of Reclamation (USBR) for the New Hogan Reservoir. Surface water is diverted from the Calaveras River. This is an existing surface water right.	Drought	2,000	Range of 0-2,000 AFY in multiple dry years
				Dry	4,900	
				Normal	4,900	
				Wet	4,900	
2. SEWD Surface Water Implementation Expansion	Stockton East Water District	In Lieu Recharge	This project relies on water from New Hogan Reservoir (Calaveras River water) and New Melones Reservoir (Stanislaus River water). This is an existing surface water right. SEWD has long-term water supply contracts with USBR for both New Hogan Reservoir and New Melones Reservoir.	Drought	4,000	Range of 0-4,000 AFY in multiple drought years
				Dry	8,000	
				Normal	19,000	
				Wet	19,000	
3. West Groundwater Recharge Basin	Stockton East Water District	Direct Recharge	This project relies on water from New Hogan Reservoir (Calaveras River water) and New Melones Reservoir (Stanislaus River water). This is an existing surface water right. SEWD has long-term water supply contracts with USBR for both New Hogan Reservoir and New Melones Reservoir. In addition to Calaveras River and Stanislaus River water, stormwater runoff will also contribute to the volume of water available for recharge.	Drought	1,500	
				Dry	4,000	
				Normal	16,000	
				Wet	16,000	

Project	Submitting GSA	Project Type	Water Source	Baseline Water Year Type	Annual Volume (AFY)	Notes
4. CSJWCD Capital Improvement Program	Central San Joaquin Water Conservation District	In-Lieu Recharge	This project relies on water from New Melones Reservoir. This is an existing surface water right. CSJWCD has long-term water supply contracts with USBR for the New Melones Unit Central Valley Project.	Drought	0	
				Dry	12,000	
				Normal	24,000	
				Wet	24,000	
5. Long-Term Water Transfer to SEWD and CSJWCD	South San Joaquin GSA	Transfers/In-Lieu Recharge	This project relies on water from New Melones Reservoir (Stanislaus River water). This is an existing surface water right (pre-1914) held by Oakdale Irrigation District (OID) and South San Joaquin Irrigation District (SSJID).	Drought	20,000	This project currently only covers the transfer of water from OID and SSJID to SEWD urban customers.
				Dry	5,000	
				Normal	0	
				Wet	0	
6. White Slough Pollution Control Facility Expansion	City of Lodi	Recycled Water/In-Lieu Recharge	Treated wastewater effluent from White Slough Water Pollution Control Facility.	Drought	3,729	
				Dry	3,729	
				Normal	3,729	
				Wet	3,729	
7. NSJWCD South System Modernization	North San Joaquin Water Conservation District	In-Lieu Recharge/ Direct Recharge	This project relies on water from the Mokelumne River. This is an existing water right held by NSJWCD (Permit 10477).	Drought	0	
				Dry	0	
				Normal	4,800	
				Wet	6,000	
8. NSJWCD Tecklenburg Recharge Project	North San Joaquin Water Conservation District	Direct Recharge	This project relies on water from the Mokelumne River. This is an existing surface water right held by NSJWCD (Permit 10477).	Drought	0	
				Dry	1,000	
				Normal	4,800	
				Wet	6,000	
				Drought	0	

Project	Submitting GSA	Project Type	Water Source	Baseline Water Year Type	Annual Volume (AFY)	Notes
9. NSJWCD South System Groundwater Banking with EBMUD	North San Joaquin Water Conservation District	In-Lieu Recharge	This project relies on water from the Mokelumne River. This is an existing water right held by East Bay Municipal Utility District (EBMUD) (Permit 10478) as per Protest Dismissal Agreement from 11/25/2014.	Dry	1,500	
				Normal	6,400	80% of wet year supply
				Wet	8,000	
10. NSJWCD North System Modernization/Lakso Recharge	North San Joaquin Water Conservation District	In-Lieu Recharge/ Direct Recharge	This project relies on water from the Mokelumne River. This is an existing surface water right held by NSJWCD (Permit 10477).	Drought	0	
				Dry	1,000	
				Normal	3,200	
				Wet	4,000	
11. Delta Water Treatment Plant Groundwater Recharge Improvements Project Geotechnical Investigation	City of Stockton	Direct Recharge	This project relies on raw water from the Delta Water Treatment Plant.	Drought	5,040	
				Dry	5,040	
				Normal	5,040	
				Wet	5,040	

Table 2: Category B Projects

Project Name	Project Type	Submitting GSA	Current Status	Time-table (initiation and completion)	Annual Volume (AFY)
Perfecting Mokelumne River Water Right	In-lieu Recharge	San Joaquin County	Planning phase	2022-2025	20,000 to 50,000
City of Manteca Advanced Metering Infrastructure	Conservation	City of Manteca	Currently underway	2019-2021	272
City of Lodi Surface Water Facility Expansion & Delivery Pipeline	In-lieu Recharge	City of Lodi	Planning phase	2030-2033	4,750
BNSF Railway Company Intermodal Facility Recharge Pond	Direct Recharge	CSJWCD	Planning phase	2020-2023	1,000
City of Stockton Advanced Metering Infrastructure	Conservation	City of Stockton	Initial study completed in 2011	2020/25-2025/28	2,000
Manaserro Recharge Project	Direct Recharge	NSJWCD	Planning phase	2019-2022*	8,000
City of Escalon Wastewater Reuse	Recycling/ In-lieu Recharge/ Transfers	SSJ GSA	Planning phase	2020-2028	672
City of Ripon Surface Water Supply	In-lieu Recharge	SSJ GSA	Design complete; environmental permitting underway	2020-2024	6,000
City of Escalon Connection to Nick DeGroot Water Treatment Plant	In-lieu Recharge	SSJ GSA	Conceptual design phase; environmental review complete	2020-2023	2,015

Project Name	Project Type	Submitting GSA	Current Status	Time-table (initiation and completion)	Annual Volume (AFY)
Farmington Dam Repurpose Project	Direct Recharge	SEWD	Preplanning phase with reconnaissance study complete	2030-2050	30,000
Recycled Water Transfer to Agriculture	Recycling/Transfers/ In-lieu Recharge	City of Manteca	Planning phase with evaluation completed in Draft Reclaimed Water Facilities Master Plan	Not determined	5,193
Mobilizing Recharge Opportunities	Direct Recharge	San Joaquin County	Early conceptual planning phase	Not determined	Not determined
NSJWCD Winery Recycled Water	Recycling/ In-Lieu Recharge/ Direct Recharge	NSJWCD	Conceptual planning and discussion	2025-2027	750
Pressurization of SSJID Facilities	Conservation	SSJ GSA	Feasibility study complete	2019-2030	30,000
SSJID Storm Water Reuse	Storm Water/ In-lieu Recharge/ Direct Recharge	SSJ GSA	Planning phase	2027-2030	1,100

3.1 GSA Managed Water

All of the Category A projects included above are recharge projects (either direct or in-lieu) that have water available to complete the project through current water rights, contracts, or existing interagency agreements. The existing water rights in the Subbasin are included in **Table 3**. These water rights are held and managed by individual agencies in the Subbasin, and it would be up to the water rights holder to determine how much water was made available for any planned or future recharge projects, including the Category A projects. Though the total water available included in **Table 3** reduces in drier water years, several agencies still have firm rights and contracts within their control aimed to maximize beneficial use in dry years when considering conjunctive use, banking, and groundwater storage projects. In addition to the total surface water rights included in **Table 3**, other supplies, such as stormwater runoff, recycled water, and water supplies from other agencies that may bank water in the subbasin in the future (e.g., EBMUD, Valley Water, etc.), may also be utilized for future Subbasin recharge projects. This water may be available for recharge by the GSAs that maintain and possess the water right. The water is currently, or is planned, for beneficial use by the holder, and GSAs are responsible for evaluating their highest and best use and how these supplies may be used to achieve sustainability.

Table 3: Total Current Water Rights and Contracts in Eastern San Joaquin Subbasin

District/ Agency	Source River/Reservoir	Water Use	Wet Year Volume (AFY)[1]	Dry Year Volume (AFY)[1]	Comments
WID	Mokelumne/ Camanche Reservoir	Agricultural/ M&I	60,000	39,000	Firm; Agreements with City of Lodi and City of Stockton
		Agricultural/ M&I	See note[3]	0	Non-firm
NSJWCD	Mokelumne/ Camanche Reservoir	Agricultural/ M&I	20,000	0	Subject to EBMUD supply and future requirements
City of Stockton	Delta/ San Joaquin River	M&I	33,600	<33,600	Can take as much water as is discharged by wastewater treatment plant
CCWD [2]	Calaveras River	Agricultural	1,900	1,900	Up to 43.5% of New Hogan yield (up to 30,928 of 71,100 AFY). Reduce by 7,800 AF if end of October New Hogan storage is less than 71,400 AF.
	New Hogan Reservoir	M&I	2,700	2,700	
SEWD	Calaveras/ New Hogan Reservoir[2]	Agricultural/ M&I	40,115	<40,115	56.5% of New Hogan yield. Reduced by 10,000 AF if end of October New

District/ Agency	Source River/Reservoir	Water Use	Wet Year Volume (AFY)[1]	Dry Year Volume (AFY)[1]	Comments
					Hogan storage is less than 71,400 AF.
		Agricultural/ M&I	27,000	<27,000	Estimated unused portion of CCWD's up to 43.5% New Hogan allocation
	Stanislaus/ New Melones Reservoir	Agricultural/ M&I	75,000	<75,000	Interim, subject to other users requirements and availability
	Stanislaus/ New Melones Reservoir	M&I	0	15,000	From agreement with CSJWCD to receive first 15,000 AF of 49,000 AF firm supply
CSJWCD	Stanislaus/ New Melones Reservoir	Agricultural	80,000	34,000	49,000 AF firm supply, 31,000 AF interim supply subject to other user's requirements
	Stanislaus/ New Melones Reservoir				other user's requirements
SSJID/ OID[4]	Stanislaus/ New Melones Reservoir	Agricultural/ M&I	600,000	<600,000	Includes agricultural use in SSJID and OID. Includes potential water sales to SEWD/CSJWCD and other out-of-district customers. Includes agreement between SSJID and City of Escalon, City of Lathrop, City of Manteca, and City of Tracy.
CDWA	Delta	Agricultural	118,000	118,000	Estimated based on current demand within Subbasin.
SDWA	Delta	Agricultural	17,000	17,000	

Notes:

[1] The volumes in this table are not necessarily authoritative and are provided for general information purposes only. The actual quantity of water available from year to year and the quantity that is actually used vary significantly.

[2] New Hogan Reservoir has an estimated "conservation storage" yield of 71,400 AFY. Stockton East Water District contract with the Bureau of Reclamation is for 56.5% of the yield, and Calaveras County Water District rights to the remaining 43.5%. CCWD currently uses approximately 3,500 AFY of its allocation.

Based on an agreement between CCWD and SEWD, SEWD currently has use of the unused portion of CCWD's allocation.

[3] Under the WID-EBMUD water right settlement agreement, 60,000 AFY is the firm portion of the Woodbridge Irrigation District water rights. 60,000 AFY is the minimum amount available to WID during any year when the inflow to Pardee Reservoir is greater than 375,000 AF. When the Pardee inflow is less than 375,000 AF, the minimum amount available to WID is 39,000 AFY. WID is entitled to divert water in excess of the 60,000 AFY under the priority of its water right licenses when such water is available at WID's point of diversion and is surplus to EBMUD's downstream commitments under the Joint Settlement Agreement. Through this water right, WID has agreements with City of Lodi and City of Stockton to provide raw water.

[4] OID and SSJID share equally rights to 600,000 AFY when available. Of its 300,000 AFY share, OID provides water to its district area, of which about 40% is within the Eastern San Joaquin Subbasin and 60% is outside. SSJID is located completely within the Subbasin and has agreements to provide water to several cities both inside and outside the Subbasin (City of Escalon, City of Lathrop, City of Manteca, and City of Tracy). Both agencies participate in water transfers or sales to out-of-district deliveries, including SEWD and CSJWCD. In years when the full allotment is not available, the amount is less than 320,000 AFY and is based on a formula which is part of the agreement with USBR

4. Updated Modeling Work: Methods

The ESJGWA has performed updated projected water budget modeling and hydrograph analysis to identify: 1) where, when, and how often established minimum thresholds may be exceeded under projected conditions using the updated definition for undesirable results (with the water year type requirement removed from the definition), 2) what the impact of planned projects will have on the Subbasin groundwater storage deficit, 3) the amount of demand and pumping reduction to keep groundwater levels above the minimum thresholds, and 4) the potential effects of climate change.

Four scenarios were analyzed using the Eastern San Joaquin Water Resources Model (ESJWRM):

- Projected Conditions Baseline (PCBL): This model run doesn't include any projects or climate change. The PCBL represents long-term hydrologic conditions of the Subbasin under the foreseeable future level of development. The future level of development represents approximately Water Year (WY) 2040 or the closest information available from planning documents, and includes urban build out to either the sphere of influence or general plan boundaries. The model update documentation is included in **Attachment 3.**

- Projected Conditions Baseline with Climate Change (PCBL-CC): This model run is the same as the PCBL, but includes estimates of climate change in datasets for model stream inflows, precipitation, and evapotranspiration as provided by DWR. The model update documentation is included in **Attachment 3.**

- Projected Conditions Baseline with Category A Projects (PCBL-PMA): This model is the same as the PCBL without climate change and includes the 11 Category A projects. The assumptions and results are included in **Attachment 2.**

- Projected Conditions Baseline with Climate Change and Category A Projects (PCBL-CC-PMA): This model is the same as the PCBL-CC and includes climate change and the 11 Category A projects. The assumptions and results are included in **Attachment 2.**

For modeling purposes in this analysis, only projects designated as Category A were considered. For additional detail on the data and assumptions that went into this analysis, see **Attachment 2** of this memorandum.

5. Updated Modeling Work: Results

5.1 Evaluating Impact of Projects on Groundwater Storage Deficit

Modeling results indicate that the Category A projects, as currently estimated in **Attachment 2,** will resolve the Subbasin overdraft condition when impacts due to climate change are not included. Without projects, the modeling shows an average overdraft of 16,300 AFY over the 52 years of the PCBL simulation. With Category A projects in place, the modelling shows a projected overdraft of -5,300 AFY on average in the PCBL-PMA (a negative number indicating the absence of an overdraft condition). The PCBL-PMA shows an average increase of 21,600 AFY of groundwater in storage when compared to the PCBL. Compared to the PCBL, with Category A projects modeled, the PCBL-PMA has 38,400 AFY less groundwater pumping due to in-lieu recharge projects, 24,500 AFY more recharge, and 28,900 AFY less stream seepage into the groundwater system. Other hydrologic groundwater budget component differences are small between the PCBL and PCBL-PMA simulations.

While the groundwater storage deficit in the PCBL is projected to be corrected through the implementation of Category A projects as seen in PCBL-PMA, the modeling shows that when climate change is factored in, there is still additional work (e.g., projects and/or management actions) that may need to be done to maintain subbasin sustainability. The PCBL water budget without projects and with climate change (PCBL-CC) shows a projected overdraft of 38,100 AFY. When projects are added in, as simulated in PCBL-CC-PMA, this overdraft amount is reduced to 15,700 AFY, but still represents continuing groundwater overdraft in the Subbasin that is not sustainable.

5.2 Identifying Areas Where Groundwater Levels May Exceed Minimum Thresholds

The groundwater level representative monitoring network well hydrographs were analyzed for the model runs completed to review the potential impact to groundwater levels that the 52 years of varying hydrologic conditions and projected demands and supplies may have. The results below discuss the hydrographs for the PCBL, PCBL-CC, PCBL-PMA, and PCBL-CC-PMA and where, when, and how often the hydrographs exceed the minimum thresholds. A full description of the process, analysis, and results, along with all the representative monitoring network hydrographs, are included in **Attachment 2.**

In the PCBL without projects model run (**Figure 1**), two representative monitoring network wells are projected to fall below their minimum thresholds (MT) for groundwater levels at some point in the 52-year projection:

- Well Swenson-3 exceeds its MT in 8 percent of total months or 15 percent of water years
- Well 01S10E04C001M exceeds its MT in 50 percent of total months or 79 percent of water years.

In the PCBL water budget scenario without projects, but with climate change factored in (PCBL-CC) (**Figure 2**), the modeling results show five representative monitoring network wells are expected to fall below their minimum thresholds at some point in the 52-year projection:

- Well 01S09E05H002 exceeds its MT in 24 percent of total months or 33 percent of water years
- Well Swenson-3 exceeds its MT in 8 percent of total months or 19 percent of water years
- Well #3 Bear Creek exceeds its MT in 8 percent of total months or 56 percent of water years
- Well Hirschfeld [OID-8] exceeds its MT in 18 percent of total months or 25 percent of water years
- Well 01S10E04C001M exceeds its MT in 82 percent of total months or 90 percent of water years).

These five wells exceeding their minimum thresholds demonstrates the need for planned projects and management actions that the ESJGWA will implement to recharge and/or offset groundwater to raise Subbasin groundwater levels.

When Category A projects are included in the ESJWRM, groundwater levels rise across the Subbasin, though the impact to levels varies from area to area. In the PCBL water budget scenario with projects included (PCBL-PMA) (**Figure 3**), projections show only one well falling below its minimum threshold for groundwater levels (Well 01S10E04C001M exceeds its MT in 8 percent of total months or 19 percent of water years) as compared to the two wells in the PCBL without Category A projects.

As seen with the five wells with exceedances in the PCBL-CC, the effects of climate change could significantly impact Subbasin groundwater overdraft and groundwater levels. In the PCBL water budget scenario with projects and climate change factored in (PCBL-CC-PMA), modeling results show three wells still falling below their minimum thresholds for groundwater in a 52-year projection:

- Well 01S09E05H002 exceeds its MT in 1 percent of total months or 4 percent of water years
- Well Hirschfeld [OID-8] exceeds its MT in 1 percent of total months or 4 percent of water years
- Well 01S10E04C001M exceeds its MT in 60 percent of total months or 79 percent of water years).

Notably, all three of these wells are clustered in the same area of the Subbasin, perhaps indicating the need for additional study or a targeted project or management action specific to this area.

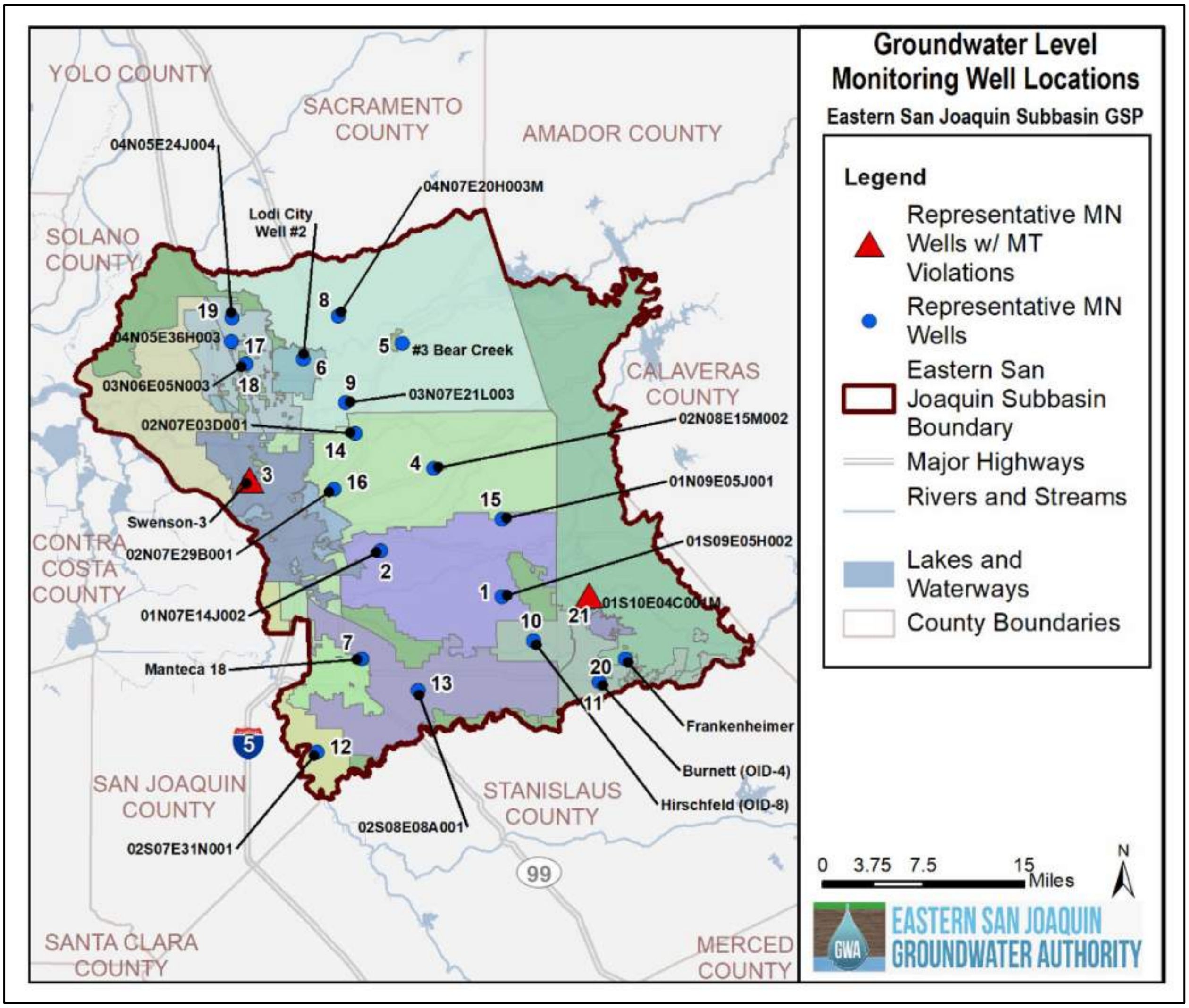


Figure 1: Projected Conditions Baseline (PCBL) Water Budget Without Projects

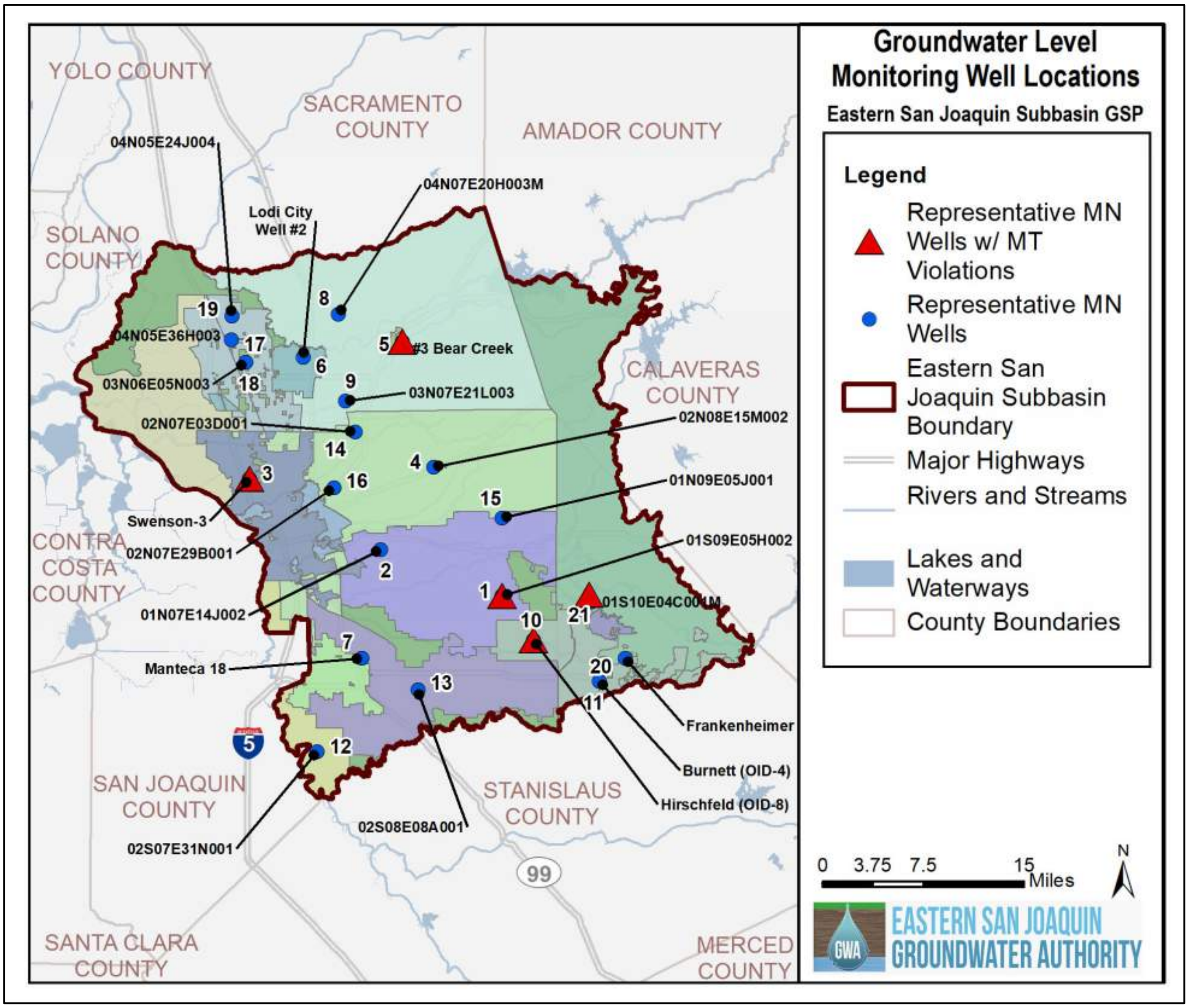


Figure 2: Projected Conditions Baseline (PCBL) Water Budget Without Projects + Climate Change

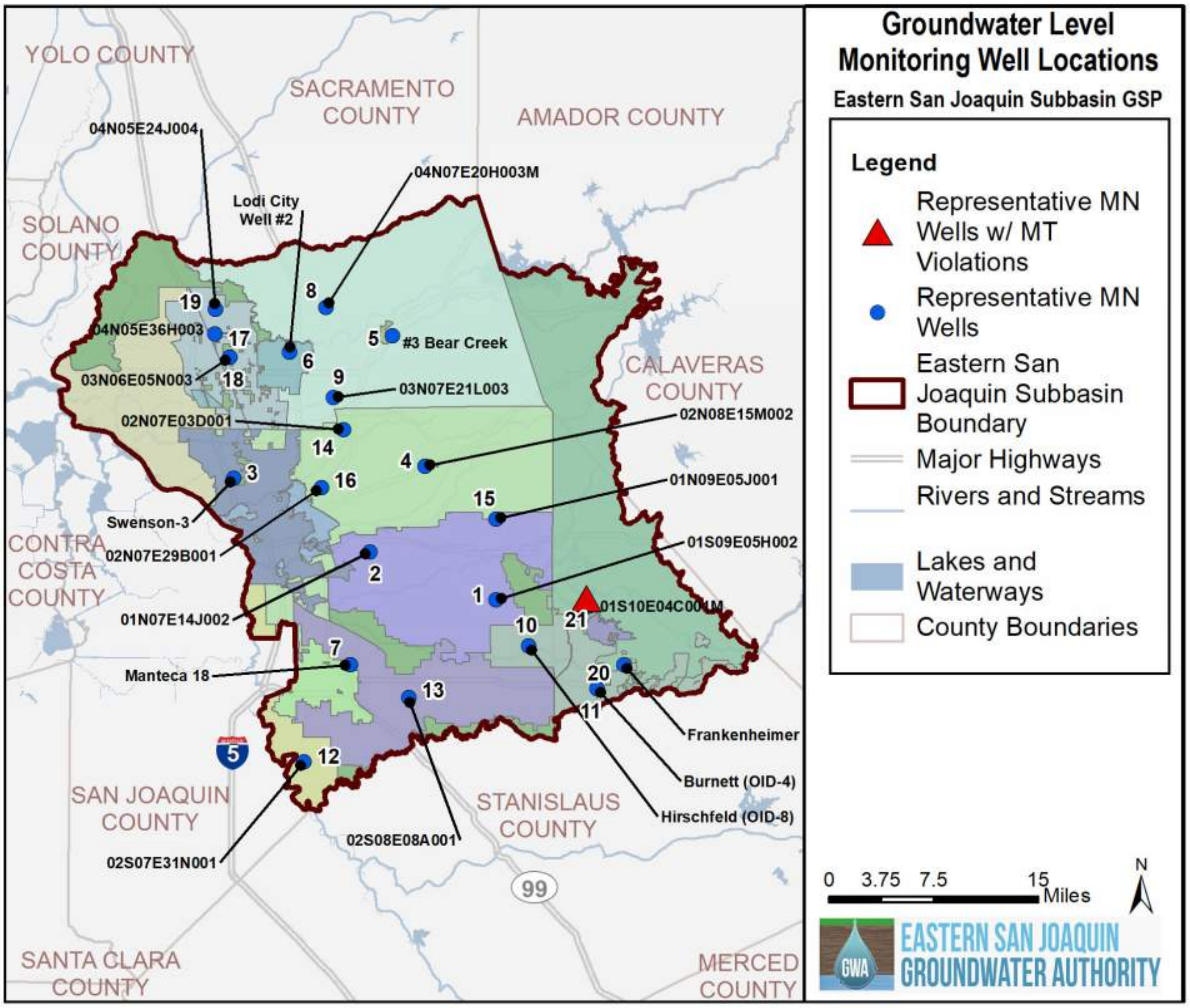


Figure 3: Projected Conditions Baseline (PCBL) Water Budget With Projects

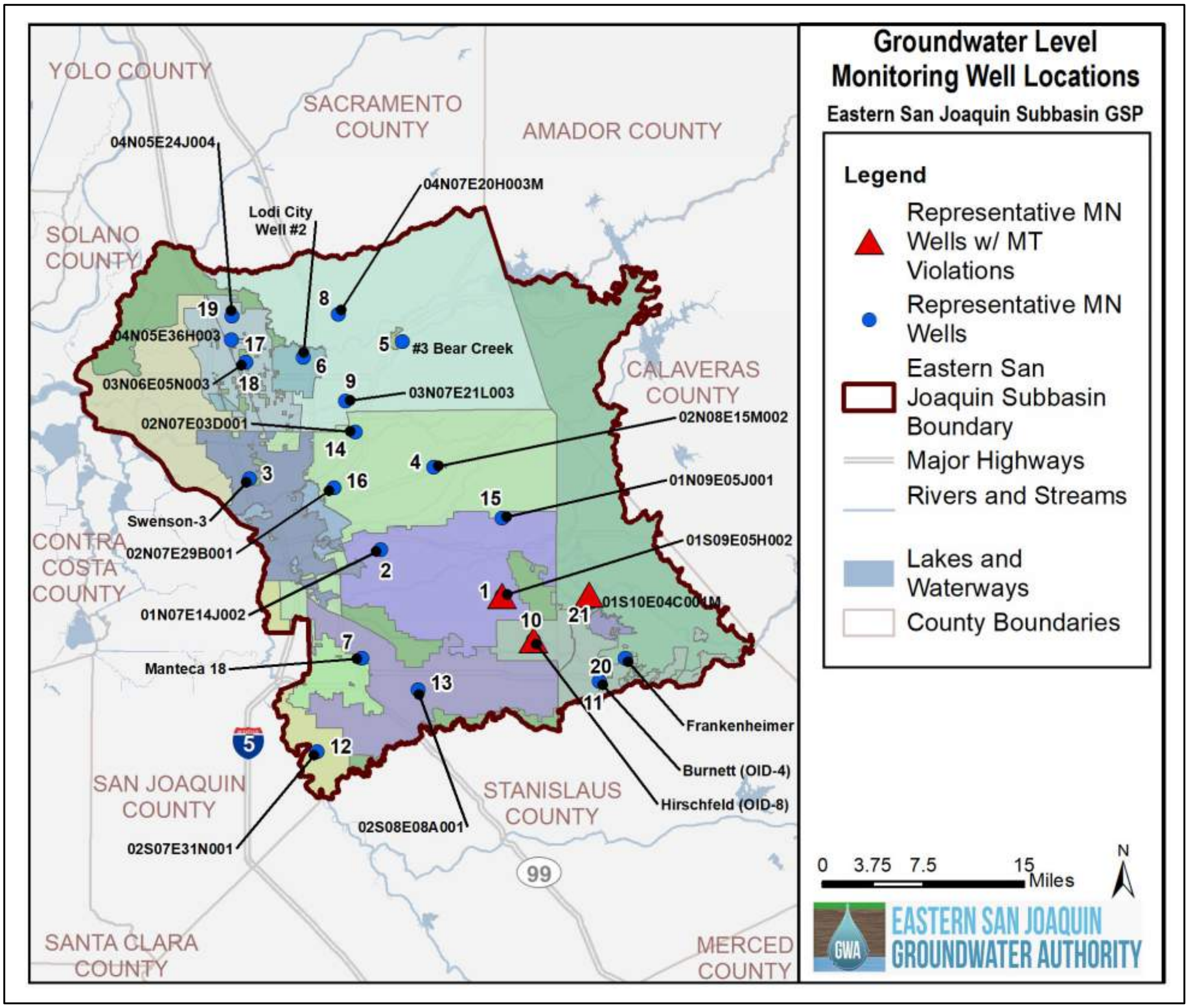


Figure 4: Projected Conditions Baseline (PCBL) Water Budget With Projects + Climate Change

An undesirable result for groundwater levels is defined as occurring when at least 25 percent of representative monitoring network wells used to monitor groundwater levels (5 of 21 wells in the Subbasin) fall below their minimum level threshold for two consecutive years. The consecutive year analysis for the model runs is covered in **Attachment 2.** The modeling results suggest that, with Category A projects implemented as planned, the Subbasin is not projected to see undesirable results within the planning timeframe of the GSP since neither model run with Category A projects has five wells with minimum threshold exceedances. However, given the undesirable result for groundwater levels projected to occur in five water years in the PCBL-CC, the GSAs need a plan to address potential minimum threshold exceedances where possible and adaptively manage around the uncertainty of climate change impacts on groundwater levels in the case that the Category A projects do not occur as anticipated.

5.3 Evaluating the Impact of Projects and Management Actions on Groundwater Levels During Dry Conditions

The hydrographs for the representative monitoring network wells tend to have the similar trends for when minimum threshold exceedances do occur. A full discussion of water year type conditions where exceedances occur is included in **Attachment 2.** According to the model results, minimum threshold exceedances occur in all water year types, though are less likely to occur in normal water years (above normal or below normal water years in the San Joaquin Valley Water Year Hydrologic Classification).

The 52 years of projected hydrology includes a range of hydrologic conditions, including three periods of multi-year droughts with at least two consecutive critical water years and surface water supplies reduced consistent to what occurred in WY 2015. Exceedances typically occur during or follow these multi-year drought periods. For the three wells with minimum threshold exceedances under climate change with Category A projects simulated (Well 01S09E05H002, Well Hirschfeld [OID-8], and Well 01S10E04C001M), Well 01S09E05H002 under the PCBL-CC-PMA exceeds its minimum threshold in September of Year 24 at the end of a sixth consecutive drought year and continues for two more months for three months total across two water years. It recovers during the following wet year and doesn't exceed again. Well Hirschfeld [OID-8] exceeds its minimum threshold at almost the same time (August of Year 24 toward the end of a sixth consecutive drought year) and continues for seven months in total across two water years before recovering. Therefore, in the case of these two wells, exceedances only occur after a prolonged drought period of just under six years. The last well, Well 01S10E04C001M, drops below its minimum threshold in the PCBL-CC-PMA in July of Year 8, which is the first of a two-year drought period. Though it comes above the minimum threshold for a few scattered months, it remains below the minimum threshold for eight consecutive water years (through Year 15). In July of Year 21 with continuing drought conditions, the groundwater level drops below the minimum threshold again and remains below for the remainder of the simulation (33 consecutive water years), even though there are scattered months where the water level recovers above the minimum threshold.

The three wells described above only represent the wells that still exceed in the case of climate change and with Category A projects (in the PCBL-CC-PMA). Across the five total wells with exceedances, the most typical time for exceedances is during or immediately after a multi-year drought. However, with project and management actions implemented, the groundwater level undesirable results do not occur in any year.

6. Conclusions

In response to Potential Corrective Actions 1(a), the ESJGWA has removed the water year type requirement from the definition of undesirable results for chronic lowering of groundwater levels. In response to Potential Corrective Actions 1(b), the ESJGWA has evaluated the impact of project management actions on groundwater levels during drought conditions. As part of this work, the ESJGWA has developed an updated immediate and near-term (within next 5 years) plan for Category A project implementation and has performed modelling analyses to better understand these projects' impact on avoiding minimum thresholds and undesirable results. Remaining projects are included in Category B (projects to be implemented longer-term) to be implemented in the case of Category A projects do not produce a response as simulated in the model and/or if additional recharge projects are required to achieve Subbasin sustainability by 2040. The GSAs are continuing to evaluate opportunities to increase supply reliability, resiliency, and efficiency, and projects may be added to the GSP priorities by the GWA as they become ready for decisions. The adaptive management strategy envisioned in the GSP is based on observation of groundwater levels, management objectives, minimum thresholds and triggers established by the GWA. The GWA is currently evaluating the funding and financing strategies that may be implemented with an eye towards an investment strategy. In addition, the ESJGWA has amended the GSP with actions and language to more specifically describe management actions that may be implemented as adaptive management measures if projects fall short of anticipated recharge and/or offset targets (See Adaptive Management actions described below). Key takeaways from these efforts are described below.

6.1 Conclusion 1: Removal of the Water Year Type Requirement Does Not Significantly Increase Projected Minimum Threshold Exceedances

In response to Potential Corrective Actions 1(a), the ESJGWA has removed the water year type requirement from the definition of undesirable results for the chronic lowering of groundwater levels. The modeling analyses, as described in the sections above, identified where, when, and how often established minimum thresholds may be exceeded under projected conditions. The modeling suggests that the removal of the water year requirement from the definition of undesirable results will not significantly increase the number of representative monitoring network wells that exceed their minimum thresholds, and therefore, is not anticipated to impact the Subbasin's overall sustainability status and avoidance of undesirable results. The modeling also evaluated demand reduction and groundwater level responses to climate change for purposes of comparison.

By proxy, undesirable results are not anticipated for reduction in groundwater storage, land subsidence or depletions of interconnected surface water. The chronic lowering of groundwater levels minimum thresholds are determined to be protective of these three sustainability indicators by the same rationale as described in the GSP. The removal of the water year type requirement from the definition of undesirable results for groundwater levels is more protective than the definition previously provided in the GSP submitted in January 2020.

6.2 Conclusion 2: With Climate Change, the Subbasin Will Likely Need to Implement Additional Projects and Management Actions

As noted previously, modelling indicates that a basin wide, average groundwater storage deficit of 15,700 AFY is anticipated under the effects of climate change, even after the implementation of Category A projects is simulated. While there is still much uncertainty around what the impacts of climate change may be, the ESJGWA should prepare for a continuing overdraft condition even with its Category A projects and will likely need to either cut back on groundwater use, add additional recharge projects, or access new or additional surface water supplies for in-lieu use. The Mokelumne River Water and Power Authority plans to perfect their Mokelumne River water right and build additional projects to utilize that water right, either by implementing previously identified projects such as those projects now in Category B or by developing new projects. Beyond this, alternative demand-side adaptive management actions will be considered as an alternative where necessary to achieve basin sustainability. Such actions could include fallowing of crops or mandatory demand reduction measures, as described below.

6.2.1 *Adaptive Management Measures that may be Considered for Implementation*

GSP Section 6.4 *Adaptive Management Strategies* provides a high-level summary of the ESJGWA's plans to evaluate additional supply-side and demand-side management actions if monitoring efforts demonstrate that the projects are not effective in achieving stated recharge and/or offset targets. However, based on comments from DWR requesting additional detail on management actions that could be implemented, the ESJGWA has developed descriptions of adaptive management measures to be considered for implementation if projects are demonstrated to not be effective in achieving Subbasin sustainability targets.

After implementation of the Category A projects, the adaptive management actions identified below could be implemented if additional measures are required to sustainably manage groundwater in the Subbasin. These adaptive management actions are programs that are not currently ready for implementation, are in the early planning stages, and do not have a firm schedules for development but rather would be implemented as needed sometime after 2026 following reevaluation of Subbasin sustainability during the 5-Year GSP Update in 2025. The sections below describe these potential programs as they are currently contemplated; none of these programs are planned for implementation in the Subbasin at this time.

6.2.1.1 Groundwater Extraction Fee with Land Use Modifications

A groundwater extraction fee or groundwater production charge could be collected from entities that own or operate an agricultural well. Revenue from these fees could then be used to pay for a variety of activities such as the construction of water infrastructure, groundwater conservation initiatives, proper construction and destruction of wells to prevent contamination, groundwater recharge and recovery projects, purchase of imported water or other supplies to replenish the groundwater basin through direct or in-lieu recharge, and/or purchasing and permanent fallowing of marginally-productive agricultural lands dependent on groundwater. Several agencies in California have already implemented such a program and have seen success in utilizing revenue to benefit the local groundwater basin. A similar methodology could be applied within the Eastern San Joaquin Subbasin.

6.2.1.2 Rotational Fallowing or Permanent Fallowing of Crop Lands

Agricultural water use can be temporarily reduced by fallowing crop lands. While this can have economic impacts to a region, the benefits may also include improved water supply reliability, improved groundwater quality, increased groundwater levels, reduced subsidence, and operational flexibility. Rotational fallowing of crop lands reduces the economic impacts to any one area by rotating the areas of fallowing. This management action could be combined with a recharge project through the application of surplus water supplies to the fallowed lands resulting in in-lieu groundwater recharge or the repurposing of the permanently fallowed lands to create wildlife habitat or some other land use benefit that is not reliant on groundwater as a supply. This management action could be implemented, if needed, to help the Subbasin work towards its sustainability goals. However, the rules by which this management action would be implemented would have to be developed by the GSAs within the Subbasin.

6.2.1.3 Conservation Programming for Demand Reduction

A demand reduction measure serves to reduce water demand, surface water losses, and/or nonessential water uses. Demand reduction measures may include a conservation rate structure or a uniform rate structure with a conservation program that achieves demand reduction. Conservation and demand management programs have been a priority for utility providers across the state for decades. Water conservation programs can by implemented by utilities to help offset the increasing demands being placed on water resources. Actions that may be considered a demand reduction measure include, but are not limited to, the following activities:

- Conservation rates
- Water efficient landscaping
- Smart meters
- Water efficient fixtures and appliances
- Water conservation education effort

Many of the GSAs in the Subbasin are currently implementing conservation programming for demand reduction. Under this management action, additional resources would be directed toward conservation programming for demand reduction such that these programs can be enhanced or expanded.

6.2.1.4 Mandatory Demand Reduction

To reduce groundwater demand to allow and encourage the recovery of the groundwater aquifer, mandatory demand reduction may be considered by the ESJGWA as needed to meet the sustainability needs of the Subbasin if projects and management actions fall short of reduction and offset targets. Mandatory measures could include establishment of a per-acre groundwater allocation, metering, extraction reporting, land retirement, and other measures to ensure land is not in production. The proposed PMAs demonstrate that these mandatory demand reduction programs are not likely to be needed in the Eastern San Joaquin Subbasin and are a low priority. Several GSAs in critically overdrafted subbasins are implementing mandatory demand reductions as part of their sustainability efforts under SGMA.

6.3 Conclusion 3: There Is a Need for Implementing Additional Projects or Management Actions in Focused Areas of The Subbasin

Modeling results indicate that, with Category A projects implemented as planned (in progress over the next five years and fully online prior to 2040), the Subbasin is not projected to see undesirable results related to chronic declines in groundwater levels within the planning timeframe of the GSP. However, there are still certain representative monitoring network wells projected to exceed their minimum thresholds for groundwater levels periodically, both with and without climate change, especially following years of extreme drought conditions. The Subbasin will need to monitor these wells as project implementation moves forward to determine if the simulated trends are accurate. Groundwater levels have been, and will continue to be, evaluated annually by the ESJGWA in order to monitor the levels against the chronic lowering of groundwater level minimum thresholds. These data are compiled and evaluated each year as part of the data assessment and production of the Annual Report, submitted to DWR each April 1. Any groundwater level exceedances would be reviewed by a technical workgroup of the ESJGWA and elevated to the Steering Committee and ESJGWA Board for further consideration and action.

Even with Category A projects, the modeling suggests that potentially there are areas where one or more representative monitoring network wells are shown to exceed their minimum thresholds. For these areas, which are outside of the area of influence of existing Category A projects, there is a demonstrated need to implement additional projects or management actions from Category B, beyond the Category A projects that are anticipated, to address groundwater levels in this portion of the groundwater basin. Modelling suggests that the benefits of projects and management actions to groundwater levels are most directly distributed locally to the project area, further supporting this approach.

ATTACHMENT 1 – DWR Consultation Initiation Letter

CALIFORNIA DEPARTMENT OF WATER RESOURCES
SUSTAINABLE GROUNDWATER
MANAGEMENT OFFICE
901 P Street, Room 313-B | Sacramento, CA 95814 | P.O. Box 942836 | Sacramento, CA 94236-0001

November 18, 2021

Kris Balaji, PMP, P.E.
Eastern San Joaquin Subbasin Plan Administrator
1810 E. Hazelton Avenue, Stockton, CA 95201
kbalaji@sjgov.org

RE: Eastern San Joaquin Subbasin - 2020 Groundwater Sustainability Plan

Dear Kris Balaji,

The Eastern San Joaquin Groundwater Authority submitted the Eastern San Joaquin Groundwater Subbasin (Subbasin) Groundwater Sustainability Plan (GSP) to the Department of Water Resources (Department) for evaluation and assessment as required by the Sustainable Groundwater Management Act (SGMA).[1]

Department staff have substantially completed an initial review of the GSP and have identified potential deficiencies (see the enclosed document) which may preclude the Department's approval.[2] Department staff have also developed potential corrective actions[3] for each potential deficiency. The potential deficiencies do not necessarily represent all deficiencies or discrepancies that the Department may identify in the GSP but focus on those deficiencies that staff believe, if not addressed, could lead to a determination that the GSP is incomplete or inadequate.[4] This letter initiates consultation between the Department, the Plan Manager, and the Subbasin's 15 groundwater sustainability agencies (GSAs) regarding the amount of time needed to address the potential deficiencies and corrective actions. The Department will issue a final determination as described under the GSP Regulations[5] no later than January 29, 2022.

If the Department determines the GSP to be incomplete, the deficiencies precluding approval would need to be addressed within a period not to exceed 180 days from the

---

[1] Water Code § 10720 et seq.
[2] 23 CCR § 355.2(e)(2).
[3] 23 CCR § 355.2(e)(2)(B).
[4] The Department recognizes that litigation regarding the GSP has been filed. The filing of litigation does not alter or affect the Department's mandate to issue its final assessment of the Agency's groundwater sustainability plan (GSP or Plan) for the basin within two years of its submission. (Water Code §10733.4(d).) Furthermore, the Department's assessment will consist of a technical review of the submitted Plan, as required by SGMA and the GSP Regulations, and the filing of the litigation did not in any way influence or affect the Department's evaluation of the Plan. The Department expresses no opinion on the claims of the parties in the pending litigation involving the GSP.
[5] 23 CCR Division 2, Chapter 1.5, Subchapter 2.

determination. A determination of incomplete would allow the GSAs to formally address identified deficiencies and submit a revised GSP to the Department for further review and evaluation. Department staff will contact you before making the final determination to discuss the potential deficiencies and the amount of time needed by the GSAs to address the potential corrective actions detailed in the enclosed document.

Materials submitted to the Department to address deficiencies must be part of the GSP. The GSAs must justify that any materials submitted are part of the revised GSP; this justification is also part of the submittal. To facilitate the Department's review of the revised GSP, the GSAs should also provide a companion document with tracked changes of modifications made to address deficiencies. The GSAs must submit the revised GSP through the DWR SGMA Portal where, as is currently available, interested parties may provide comments on submitted materials to the Department.

Department staff will work expeditiously to review materials submitted to address deficiencies and to evaluate compliance of the revised GSP. The Department will keep a GSP status designated as incomplete during its review of the submitted materials. The Department could subsequently approve an incomplete GSP if the GSAs have taken corrective actions to address deficiencies identified by the Department within a period not to exceed 180 days from the determination. The Department could also issue a determination of inadequate for an incomplete GSP if the Department, after consultation with the State Water Resources Control Board, determines the GSAs have not taken sufficient actions to correct the deficiencies identified by the Department.

If you have any questions, please do not hesitate to contact the Sustainable Groundwater Management Office staff by emailing sgmps@water.ca.gov.

Thank you,

Paul Gosselin

Paul Gosselin
Deputy Director for Sustainable Groundwater Management

Enclosure:

1. Potential Deficiencies and Corrective Actions

Potential Deficiencies and Corrective Actions

Department of Water Resources (Department) staff have identified deficiencies regarding the Eastern San Joaquin Subbasin (Subbasin) Groundwater Sustainability Plan (GSP) that may preclude the Department's approval. Therefore, consistent with the GSP Regulations, Department staff are considering corrective actions the Subbasin's groundwater sustainability agencies (GSAs) should review to determine whether and how the deficiencies can be addressed. The deficiencies and potential corrective actions are explained below, including the general regulatory background, the specific deficiencies identified in the GSP, and specific actions to address the deficiencies. The specific actions identified are potential corrective actions until the Department makes a final determination.

General Background

Potential deficiencies identified in the Eastern San Joaquin Subbasin GSP relate to the development and documentation of sustainable management criteria, including undesirable results and minimum thresholds that define when undesirable results may occur.

The Department's GSP Regulations describe several required elements of a GSP under the heading of "Sustainable Management Criteria"[6], including undesirable results, minimum thresholds, and measurable objectives. These components of sustainable management criteria must be quantified so that GSAs, the Department, and other interested parties can monitor progress towards sustainability in a basin consistently and objectively.

A GSA relies on local experience, public outreach and involvement, and information about the basin it has described in the GSP basin setting (i.e., the hydrogeologic conceptual model, the description of current and historical groundwater conditions, and the water budget), among other factors, to develop criteria for defining undesirable results and setting minimum thresholds and measurable objectives.[7]

The Sustainable Groundwater Management Act (SGMA) defines sustainable groundwater management as the management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results.[8] Avoidance of undesirable results is thus explicitly part of sustainable groundwater management as established by SGMA and critical to the success of a GSP.

The definition of undesirable results is critical to establishing an objective method to define and measure sustainability for a basin. As an initial matter, SGMA provides a

---

[6] 23 CCR § Article 5, Subarticle 3.
[7] 23 CCR §§ 354.8, 354.10, 354.12 *et seq*.
[8] Water Code § 10721(v).

qualitative definition of undesirable results as "one or more" of six specific "effects caused by groundwater conditions occurring throughout the basin."[9]

GSAs define, in their GSPs, the specific significant and unreasonable effects that would constitute undesirable results and the groundwater conditions that would produce those results in their basins.[10] The GSAs' definition must include a description of the processes and criteria relied upon to define undesirable results and describe the effect of undesirable results on the beneficial uses and users of groundwater, surface land uses (for subsidence), and surface water (for interconnected surface water).[11]

SGMA leaves the task of establishing undesirable results and setting thresholds largely to the discretion of the GSAs, subject to review by the Department. In its review, the Department requires a thorough and reasonable analysis of the groundwater conditions and the associated effects the GSAs must manage the groundwater basin to avoid, and the GSAs' stated rationale for setting objective and quantitative sustainable management criteria to prevent those undesirable conditions from occurring.[12] If a GSP does not meet this requirement, the Department cannot evaluate the GSAs' likelihood of achieving their sustainability goal. That does not necessarily mean that the GSP or its objectives are inherently unreasonable; rather, the Department cannot evaluate whether the GSP's implementation would successfully achieve sustainable management if it is unclear what undesirable conditions the GSAs seek to avoid.

Potential Deficiency 1. The GSP lacks sufficient justification for identifying that undesirable results for chronic lowering of groundwater levels, subsidence, and depletion of interconnected surface waters can only occur in consecutive non-dry water year types. The GSP also lacks sufficient explanation for its chronic lowering of groundwater levels minimum thresholds and undesirable results.

1 The first potential deficiency relates to the GSP's requirement of two consecutive non-dry (i.e., below normal, above normal, or wet) water-year types and the exclusion of dry and critically dry water-year types in the identification of undesirable results for chronic lowering of groundwater levels, and, by proxy, land subsidence and depletions of interconnected surface water.

Background

Related to this potential deficiency, SGMA defines the term "Undesirable Result," in part, as one or more of the following effects caused by groundwater conditions occurring throughout the basin:[13]

---

[9] Water Code § 10721(x).

[10] California Department of Water Resources, Best Management Practices for the Sustainable Management of Groundwater: Sustainable Management Criteria (Draft), November 2017.

[11] 23 CCR §§ 354.26(b), 354.28(c)(5), 354.28(c)(6).

[12] 23 CCR § 355.4(b)(1).

[13] Water Code § 10721(x).

- Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon. Overdraft during a period of drought is not sufficient to establish a chronic lowering of groundwater levels if extractions and groundwater recharge are managed as necessary to ensure that reductions in groundwater levels or storage during a period of drought are offset by increases in groundwater levels or storage during other periods.
- Significant and unreasonable land subsidence that substantially interferes with surface land uses.
- Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water.

Potential Deficiency Details

Department staff identified two areas of concern, described below, which, if not addressed, may preclude approval of the GSP. Regarding the first area of concern, the GSP identifies that an undesirable result occurs "when at least 25 percent of representative monitoring wells used to monitor groundwater levels (5 of 20 wells in the Subbasin) fall below their minimum level thresholds for two consecutive years that are categorized as non-dry years (below-normal, above-normal, or wet), according to the San Joaquin Valley Water Year Hydrologic Classification." The GSP further states that "the lowering of groundwater levels during consecutive dry or critically-dry years is not considered to be unreasonable, and would therefore not be considered an undesirable result, unless the levels do not rebound to above the thresholds following those consecutive non-dry years."[14]

1.1 Department staff find that the water-year type requirement in the definition of the undesirable result for chronic lowering of groundwater levels (i.e., two consecutive non-dry years) is not consistent with the intent of SGMA. The water-year type requirement could potentially allow for unmanaged and continued lowering of groundwater levels under certain hydrologic or climatic conditions that have occurred historically. A review of historical San Joaquin Valley water-year type classifications[15] indicates the potential for dry periods without the occurrence of a second consecutive non-dry year to persist for greater than ten years (see, e.g., the 11 years from water years 1985 through 1995). Department staff also note that concurrent below normal, above normal, or wet years occurred in only five of the last twenty water years from 2001 through 2020. Because of this definition, GSAs in the Subbasin could disregard potential impacts of groundwater level declines below the minimum thresholds during extended periods of dry years, even if interrupted by normal or wet years.

---

[14] ESJ GSP, p. 253.

[15] Chronological Reconstructed Sacramento and San Joaquin Valley Water Year Hydrologic Classification Indices, Water Year 1901 through 2020. California Department of Water Resources, https://cdec.water.ca.gov/reportapp/javareports?name=WSIHIST.

Department staff also find this methodology inconsistent with other portions of the GSP. For example, while describing measurable objectives for groundwater levels, the GSP states, “the margin of operational flexibility is intended to accommodate droughts, climate change, conjunctive use operations, or other groundwater management activities. The margin of operational flexibility is defined as the difference between the minimum threshold and the measurable objective.”[16] Based on these statements, it appears the 1.2 minimum thresholds already accommodate drought conditions, so it is unclear why the GSP's definition of undesirable results further excludes minimum threshold exceedances during dry water years. (See Potential Corrective Action 1a.)

1.3 SGMA states that “overdraft during a period of drought is not sufficient to establish a chronic lowering of groundwater levels if extractions and groundwater recharge are managed as necessary to ensure that reductions in groundwater levels or storage during a period of drought are offset by increases in groundwater levels or storage during other periods.”[17] If the GSAs intended to incorporate this concept into their definition of the undesirable result for chronic lowering of groundwater levels, the GSP fails to identify specific extraction and groundwater recharge management actions the GSAs would implement[18] or otherwise describe how the Subbasin would be managed to offset, by increases in groundwater levels or storage during other periods, dry year reductions of groundwater storage. The GSP identifies many projects that, once implemented, may lead to the elimination of long-term overdraft conditions in the Subbasin. However, the GSP does not sufficiently detail how projects and management actions, in conjunction with the proposed chronic lowering of groundwater levels sustainable management criteria, will offset drought-related groundwater reductions and avoid significant and unreasonable impacts when groundwater level minimum thresholds are potentially exceeded for an extended period in the absence of two consecutive non-dry years. (See Potential Corrective Action 1b.)

1.4 As noted above, the GSP states that minimum thresholds developed for chronic lowering of groundwater levels serve as proxies for subsidence[19] and depletion of interconnected surface waters.[20] Therefore, Department staff assume the GSAs intend to apply the same water-year type criteria to undesirable results for those sustainability indicators (i.e., land subsidence or depletion of interconnected surface water undesirable results do not occur until groundwater levels exceed the thresholds for two consecutive non-dry water years). However, where SGMA acknowledges that groundwater level declines during drought periods are not sufficient to cause an undesirable result for chronic lowering of groundwater levels, the statute does not similarly provide an exception for subsidence or stream depletion during periods of drought. (See Potential Corrective Action 1c.)

---

[16] ESJ GSP, p. 259.
[17] Water Code § 10721(x)(1).
[18] 23 CCR § 354.44(b)(9).
[19] ESJ GSP, p. 270.
[20] ESJ GSP, p. 271.

2 Department staff's second area of concern is the GSP's evaluation of the effects of the proposed minimum thresholds and undesirable results on beneficial uses and users of groundwater. The GSP identifies that the chronic lowering of groundwater levels could cause undesirable results from wells going dry, reductions in pumping capacities, increased pumping costs, the need for deeper well installations or lowering of pumps, and adverse impacts to environmental uses and users.[21] The GSP builds an analysis of domestic wells going dry into its minimum thresholds, thereby considering the factors of wells going dry and the need for deeper well installations. However, it does not address how the management criteria address the other factors identified by the GSAs as potential undesirable results, including reductions in pumping capacity or increased pumping costs for shallow groundwater users, or adverse impacts to environmental uses and users. 2.1

2.2 The GSAs set minimum thresholds in the Subbasin at the shallower of the 10th percentile domestic [or municipal] well depth or the historical low groundwater levels with a subtracted buffer value, which the GSP states allows for operational flexibility.[22] These minimum threshold values generally allow groundwater levels to decline below historic lows; minimum thresholds defined using the buffer value approach allow twice the historical drawdown from the shallowest recorded groundwater levels.[23] Aside from the GSP's domestic well analysis, the only description of how minimum thresholds were evaluated to avoid undesirable results appears to be the statements that "for the majority of the Subbasin, GSA representatives identified no undesirable results, even if groundwater were to reach historical low groundwater levels" and that no GSA indicated undesirable results would occur "if the minimum threshold was set deeper than the [historic low] based on their understanding."[24] The GSP provides no further explanation or description of how the individual GSAs concluded that there would be no undesirable results based on the minimum thresholds.

2.3 The GSP only considers an undesirable result to occur for groundwater levels in the Subbasin when at least 25 percent of representative monitoring wells (5 of 20 wells) fall below their minimum threshold value for two consecutive non-dry water years.[25] The GSP does not justify or discuss how the GSAs developed the 25 percent threshold, nor does it explain or disclose the potential impacts anticipated during extended drier climate conditions using this threshold. In other words, the proposed management program may lead to potential effects on domestic wells or other beneficial uses and users during prolonged dry- or below-normal periods, and that information should, at a minimum, be disclosed and considered in the GSP. (See Potential Corrective Action 1d.)

If, after considering this potential deficiency, the GSAs retain minimum thresholds that allow for continued lowering of groundwater levels, it is reasonable to assume that some

---

[21] ESJ GSP, p. 253.
[22] ESJ GSP, p. 254.
[23] ESJ GSP, p. 258.
[24] ESJ GSP, p. 255.
[25] ESJ GSP, p. 253.

groundwater well impacts (e.g., loss of production capacity) will occur during the implementation of the GSP. SGMA requires GSAs to consider the interests of all groundwater uses and users and to implement their GSPs to mitigate overdraft conditions.[26] Implementing specific projects and management actions prevents undesirable results and achieves the sustainable yield of the basin. The GSAs should
2.4 describe how projects and management actions would address drinking water impacts due to continued overdraft between the start of GSP implementation and the achievement of the sustainability goal. If the GSP does not include projects or management actions to address drinking water impacts, the GSP should contain a thorough discussion, with supporting facts and rationale, explaining how and why GSAs determined not to include actions to address those impacts from continued groundwater lowering below pre-SGMA levels. (See Potential Corrective Action 1e.)

Additionally, related to the groundwater level declines allowed for by the GSA's minimum
2.5 thresholds, the GSAs have not explained how those groundwater level declines relate to the degradation of groundwater quality sustainability indicator. GSAs must describe, among other items, the relationship between minimum thresholds for a given sustainability indicator (in this case, chronic lowering of groundwater levels) and the other sustainability indicators.[27] The GSAs generally commit to monitoring a wide range of water quality constituents but they have only developed sustainable management criteria for total dissolved solids because they state they have not observed a causal nexus between groundwater management and degradation associated with the other constituents. While Department staff are not aware of evidence sufficient to conclude that the GSAs acted unreasonably by focusing on total dissolved solids, it is clear that the GSAs did not consider, or at least did not document, the potential for degradation to occur due to further lowering of groundwater levels beyond the historic lows. (See Potential Corrective Action 1f.)

Potential Corrective Action 1

a) Department staff believe the management approach described in the GSP, which couples minimum thresholds and measurable objectives that account for operational flexibility during dry periods with a definition of undesirable results that disregards minimum threshold exceedances in all years except consecutive below normal, above normal, or wet years, to be inconsistent with the objectives of SGMA. Therefore, the GSAs should remove the water-year type requirement from the GSP's undesirable result definition.
b) The GSP should be revised to include specific projects and management actions the GSAs would implement to offset drought-year groundwater level declines.
c) The GSAs should thoroughly explain how their approach avoids undesirable results for subsidence and depletion of interconnected surface waters, as SGMA does not

---

[26] 23 CCR § 355.4(b)(4), 355.4(b)(6).
[27] 23 CCR § 354.28(b)(2).

include an allowance or exemption for those conditions to continue in periods of drought.

d) Removing the water-year type requirement from the definition of an undesirable result (item a, above) would result in a GSP with groundwater level minimum thresholds designed to be generally protective of 90 percent of domestic wells regardless of regional hydrologic conditions. In that scenario, the GSAs should explain the rationale for determining that groundwater levels can exceed those thresholds at 25 percent of monitoring sites for two consecutive years before the effects would be considered significant and unreasonable. The GSAs should also explain how other factors they identified as "potential undesirable results" (e.g., adverse impacts to environmental uses and users) factored into selecting minimum thresholds and describe anticipated effects of the thresholds on beneficial uses and users of groundwater. Furthermore, the GSAs should explain whether other drinking water users that may rely on shallow wells, such as public water systems and state small water systems, were considered in the GSAs' site-specific thresholds. If not, the GSAs should conduct outreach with those users and incorporate their shallow wells, as applicable, into the site-specific minimum thresholds and measurable objectives.

e) The GSAs should revise the GSP to describe how they would address drinking water impacts caused by continued overdraft during the period between the start of GSP implementation and achieving the sustainability goal. If the GSP does not include projects or management actions to address those impacts, the GSP should contain a thorough discussion, with supporting facts and rationale, explaining how and why the GSAs determined not to include specific actions to address drinking water impacts from continued groundwater lowering below pre-SGMA levels.

f) The GSP should be revised to explain how the GSAs will assess groundwater quality degradation in areas where further groundwater level decline, below historic lows, is allowed via the minimum thresholds. The GSAs should further describe how they will coordinate with the appropriate groundwater users, including drinking water, environmental, and irrigation users as identified in the GSP. The GSAs should also discuss efforts to coordinate with water quality regulatory agencies and programs in the Subbasin to understand and develop a process for determining if continued lowering of groundwater levels is resulting in degraded water quality in the Subbasin during GSP implementation.

Potential Deficiency 2. The GSP does not provide enough information to support the use of the chronic lowering of groundwater level sustainable management criteria and representative monitoring network as a proxy for land subsidence.

Background

The GSP Regulations state that minimum thresholds for land subsidence should identify the rate and extent of subsidence that substantially interferes with surface land uses and may lead to undesirable results. These quantitative values should be supported by: [28]

- The identification of land uses or property interests potentially affected by land subsidence;
- An explanation of how impacts to those land uses or property interests were considered when establishing minimum thresholds;
- Maps or graphs showing the rates and extents of land subsidence defined by the minimum thresholds.

The GSP Regulations allow the use of groundwater elevations as a proxy for land subsidence. However, GSAs must demonstrate a significant correlation between groundwater levels and land subsidence and must demonstrate that groundwater level minimum thresholds represent a reasonable proxy for avoiding land subsidence undesirable results. Additionally, the GSAs must demonstrate how the monitoring network is adequate to identify undesirable results for both metrics.

Potential Deficiency Details

3.1 Department staff find that the GSP does not adequately identify or define minimum thresholds and undesirable results for land subsidence. The GSP also does not provide adequate justification and explanation for using the groundwater level minimum thresholds and representative monitoring network as a proxy for land subsidence.

3.2 Generally, the GSP identifies that irrecoverable loss of groundwater storage and damage to infrastructure, including water conveyance facilities and flood control facilities, are potential impacts of land subsidence.[29] However, the GSP does not identify specific infrastructure locations, particularly those associated with public safety, in the Subbasin and the rate and extent of subsidence that would substantially interfere with those land surface uses and may lead to undesirable results. Additionally, without identifying infrastructure considered at risk for interference from land subsidence, Department staff cannot evaluate whether the groundwater level representative monitoring network is adequate to detect potential subsidence-related impacts.

3.3 Department staff find the GSP does not provide adequate evidence to demonstrate a significant correlation between groundwater levels and land subsidence in the Subbasin.

---

[28] 23 CCR § 354.28(c)(5).
[29] ESJ GSP, p. 269.

Without explaining this correlation, the Department cannot evaluate whether the groundwater level minimum thresholds and associated conditions required for identifying an undesirable result would protect against significant and unreasonable impacts related to land subsidence. The GSP states a significant correlation exists between groundwater levels and land subsidence, with lowering groundwater levels driving further land
3.4 subsidence.[30] Department staff agree with this general statement. However, the GSP fails to provide adequate evidence to evaluate further this correlation, specifically concerning potential subsidence caused by groundwater levels falling below historic lows, as would be allowed by the groundwater level minimum thresholds set in the GSP.

The GSP's justification for using the proposed groundwater level minimum thresholds as a proxy for land subsidence appears to rely mainly on an incomplete analysis and a data set with significant data gaps. The GSP states there are no historical records of significant and unreasonable land subsidence in the Subbasin.[31] The GSP also states that there is a lack of direct land subsidence monitoring in the Subbasin.[32] The GSP uses this absence of historical records to assert that historically dewatered geologic units are not compressible and, therefore, not at risk for land subsidence. Although groundwater level minimum thresholds are below historic lows, the GSP states that the GSAs do not expect further declines in groundwater levels to dewater materials deeper than 205 feet below ground surface (the deepest groundwater level minimum threshold value in the Subbasin).[33] The GSP states that subsurface materials encountered up to this depth are the same [non-compressible] geologic units that have been historically dewatered.

Department staff find multiple aspects of this justification speculative and not supported
3.5 by the best available science. First, the GSP presents no analysis of historic groundwater levels or historically dewatered subsurface materials to support the conclusion that the geologic units are not compressible. Second, the GSP does not provide an evaluation
3.6 showing how additional declines in groundwater levels would only affect subsurface materials similar to those which have been historically dewatered. Third, the GSP is
3.7 unclear on whether the conditions required to identify an undesirable result for chronic lowering of groundwater levels in the Subbasin are also required to identify an undesirable result for land subsidence. Management proposed in the GSP could allow groundwater level minimum thresholds to be exceeded in periods where two consecutive non-dry years do not occur, which does not support the claim that only materials up to the deepest groundwater level minimum threshold (205 feet below ground surface) will be dewatered.

Department staff note that the legislature intended that implementation of SGMA would avoid or minimize subsidence[34] once GSAs achieve the sustainability goal for a basin. Without analysis examining how allowable groundwater levels below those historically

---

[30] ESJ GSP, p. 270.
[31] ESJ GSP, p. 269.
[32] ESJ GSP, p. 270.
[33] ESJ GSP, p. 270.
[34] Water Code § 10720.1(e).

experienced in the Subbasin may affect land subsidence, Department staff cannot determine if the GSP adequately avoids or minimizes land subsidence. While SGMA does not require prevention of all land subsidence, the GSP does not provide sufficient evidence to conclude that the proposed chronic lowering of groundwater level minimum thresholds are adequate to detect and avoid land subsidence undesirable results.

Potential Corrective Action 2

The GSAs must provide detailed information to demonstrate how the use of the chronic lowering of groundwater level minimum thresholds are sufficient as a proxy to detect and avoid significant and unreasonable land subsidence that substantially interferes with surface land uses. Alternatively, the GSAs could commit to utilizing direct monitoring for subsidence, e.g., with remotely sensed subsidence data provided by the Department. In that case, the GSAs should develop sustainable management criteria based on rates and extents of subsidence. Department staff suggest the GSAs consider and address the following issues:

1. The GSAs should revise the GSP to identify the total subsidence that critical infrastructure in the Subbasin can tolerate during GSP implementation. Support this identification with information on the effects of subsidence on land surface beneficial uses and users and the amount of subsidence that would substantially interfere with those uses and users.
2. The GSAs should revise the GSP to document a significant correlation between groundwater levels and specific amounts or rates of land subsidence. The analysis should account for potential subsidence related to groundwater level declines below historical lows and further declines that are allowed to exceed minimum thresholds (i.e., during non-consecutive non-dry years, if applicable based on the resolution to Potential Deficiency 1, above). This analysis should demonstrate that groundwater level declines allowed during GSP implementation are preventative of the rates and magnitudes of land subsidence considered significant and unreasonable based on the identified infrastructure of concern. If there is not sufficient data to establish a correlation, the GSAs should consider other options such as direct monitoring of land subsidence (e.g., remotely sensed data provided by the Department, extensometers, or GPS stations) until such time that the GSAs can establish a correlation.
3. The GSAs should explain how the groundwater level representative monitoring network is sufficient to detect significant and unreasonable subsidence that may substantially interfere with land uses, specifically any identified infrastructure of concern. If the groundwater level monitoring network alone is not adequate, based on specific infrastructure locations, Department staff suggest incorporating continued analysis of available InSAR data to cover areas with data gaps.

ATTACHMENT 2 – Assumptions and Results for Category A Projects in ESJWRM

TECHNICAL MEMORANDUM

TO:	Eastern San Joaquin Groundwater Authority Technical Advisory and Legal/Policy Committees
PREPARED BY:	Sara Miller and Jingnan Zhou (Woodard & Curran)
REVIEWED BY:	Leslie Dumas (Woodard & Curran)
DATE:	June 2, 2022
RE:	Assumptions and Results for Category A Projects in ESJWRM

The goal of this technical memorandum is to document the Projects & Management Actions (PMAs) selected for simulation in the Eastern San Joaquin Water Resources Model (ESJWRM), the assumptions made about potential project volumes and timing, and results of the model runs.

Initially, all the projects from the Eastern San Joaquin Groundwater Subbasin (ESJ Subbasin) Groundwater Sustainability Plan (GSP) and 2022 Sustainable Groundwater Management (SGM) Grant Program's SGMA Implementation Round 1 application were considered. Based on updates in the annual report and information from representatives of the Groundwater Sustainability Agencies (GSAs) in the Eastern San Joaquin Groundwater Basin Authority (ESJGBA) Technical Advisory Committee (TAC), these projects were categorized as Category A or B based on how likely they were to be online by 2040 (and likely to advance in the next five years) and if they already had the necessary water rights and/or agreements to proceed with the project. Eight projects were initially sorted into Category A and individual meetings with the project proponents identified several additional projects that were already moving forward or were already operational; these additional projects were also added to Category A, for a total of 13 projects. Two projects were removed due to a lack of information (project descriptions included in Appendix B), for a total of 11 projects.

1. Background on Model

The Category A projects are added to the information in two existing model runs: the ESJWRM Projected Condition BaseLine (PCBL) Version 2.0 and Projected Condition BaseLine with Climate Change (PCBL-CC) Version 2.0 (Woodard & Curran, 2022). Both of these projected conditions model runs are different from the versions presented in the GSP (Version 1.0). The Version 2.0 PCBL and PCBL-CC were updated in 2022, following on the historical model update and recalibration completed in 2021 (Woodard & Curran, 2022). The PCBL uses 52 years of hydrology data from water years (WY) 1969 through 2020 (October 1968 through September 30, 2020). The PCBL-CC uses all the same information as the PCBL, with changes to represent climate change conditions (2070 central tendency) impacting the stream inflows, evapotranspiration, and precipitation. The PCBL and PCBL-CC represent estimated long-term hydrologic conditions of the Subbasin under the foreseeable future level of development. The future level of development represents approximately water year 2040 or the closest information available from planning documents.

The 52 years of the PCBL and PCBL-CC represent a range of hydrologic conditions, as identified by the water year types in the San Joaquin Valley Water Year Hydrologic Classification published by DWR, which classifies water years 1901 through 2020 as Wet (W), Above Normal (AN), Below Normal (BN), Dry (D), and Critical

(C) based on inflows to major reservoirs or lakes. A description of how this index is calculated and the specific data used to calculate this index is available online from CDEC at http://cdec.water.ca.gov/cgi-progs/iodir/WSIHIST. To simplify assumptions for future level of development water supplies and demands included in the PCBL and PCBL-CC, the five San Joaquin Valley Water Year Hydrologic Classification water year types were aggregated into three baseline water year types. Critical and Dry years are combined into one category in the baseline water year types (called Dry years), Above Normal and Below Normal years are also combined into one category (Normal years), and Wet years remain in one category (called Wet years). To capture future extreme dry year periods with multiple dry years in the baseline where water supplies and demands were purposely reduced, the following 10 water years were designated as Drought periods: 1976-1977, 1987-1992, and 2014-2015. These four baseline water year types are also described in the documentation for the updated PCBL (Woodard & Curran, 2022).

2. Category A Projects

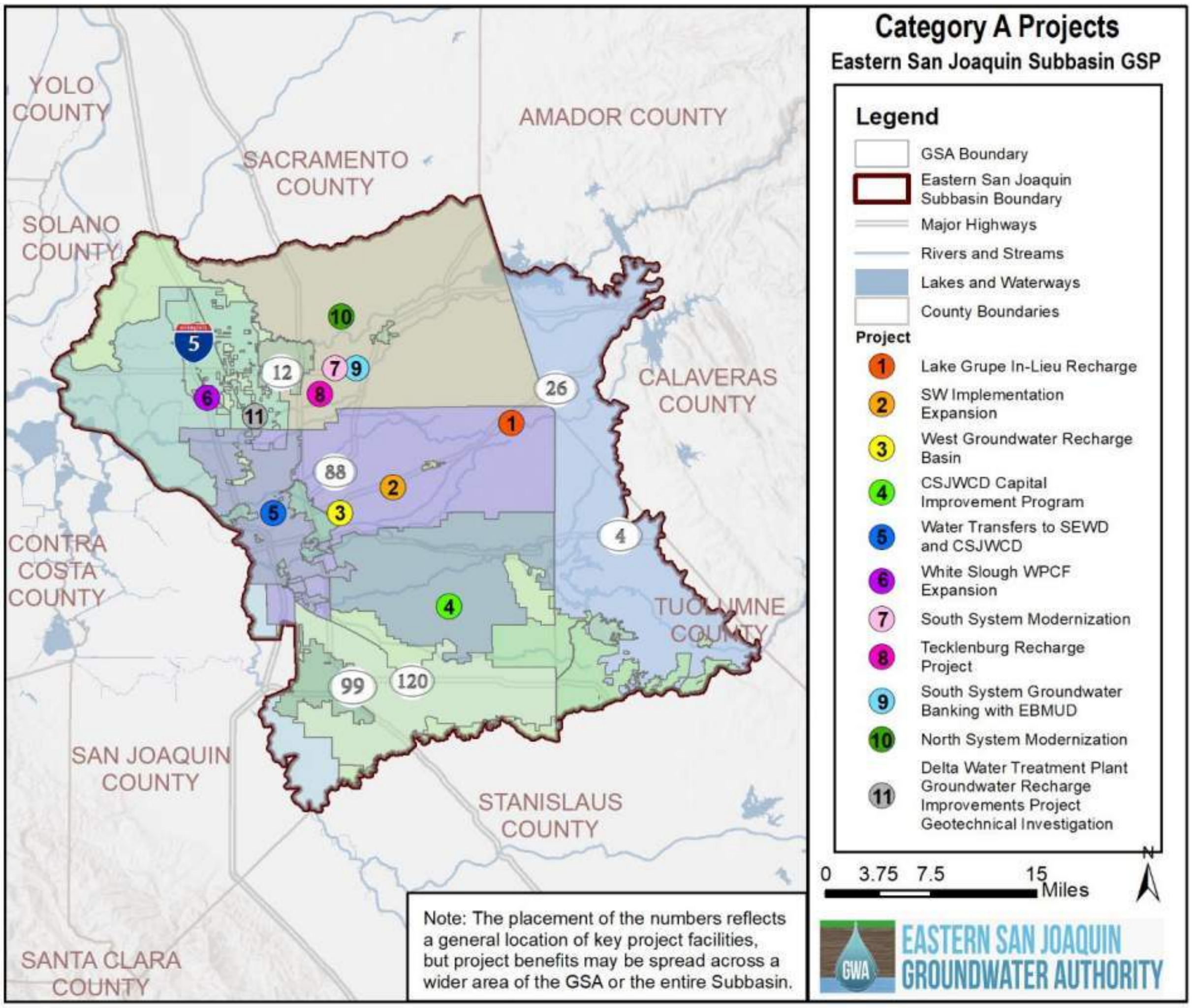
The version of the models including Category A projects are the Projected Condition BaseLine with Category A Projects and Management Actions (PCBL-PMA) and Projected Condition BaseLine with Climate Change and Category A Projects and Management Actions (PCBL-CC-PMA). For these model runs, all projects are assumed to be online and fully operational. Figure 1 shows the general locations of where the delivery of water is expected to occur.

All of the projects discussed below are either in-lieu recharge projects, direct recharge projects, or a combination of the two types, most of which utilize additional surface water coming from the major streams that cross ESJ Subbasin. All of these projects are simulated in ESJWRM as additional surface water diversions in the model. Each project contains a brief description of the proposed version of the project, which may have been updated since the description in the GSP or other documents, and any assumptions made in simulating the projects in ESJWRM. Since all volumes given below are annual, monthly estimates were assumed by using similar surface water diversions already included in ESJWRM to develop monthly distributions for the annual amounts.

The projects below are listed in no particular order, though projects submitted by the same GSA are grouped together. All information included in this document was the best available estimate at the time and is not necessarily representative of the final design or construction of the projects. Additionally, the Subbasin may choose to pursue projects not included in this technical memorandum in order to meet the needs of SGMA.

In total, 11 Category A projects have been identified. Six are in-lieu recharge projects, three are direct recharge projects, and two are a combination of in-lieu recharge and direct recharge. Overall, the projects below include in-lieu recharge for agricultural use (7 projects) with deliveries excluding assumed losses with an average of 39,700 acre-feet per year (AFY) (ranging from 9,500-56,300 AFY depending on baseline year type), in-lieu recharge for urban use (1 project) of 5,000 AFY or 20,000 AFY only in Dry and Drought baseline water years, and direct recharge (5 projects) with an average of 21,200 AFY (ranging from 6,500-32,000 AFY depending on baseline year type). Note that these project counts include those projects that include components of both in-lieu recharge and direct recharge.

Figure 1: General Location of Category A Projects



2.1 Lake Grupe In-Lieu Recharge

Submitting GSA: Stockton East Water District (SEWD)

Project Source: GSP Project #1 (Chapter 6.2.4.1) and personal communication with Scot Moody (SEWD) and Justin Hopkins (SEWD) on April 21, 2022

Project Assumptions Confirmed By: Justin Hopkins (SEWD) on May 9, 2022 and Jeanne Zolezzi (Herum\Crabtree\Suntag) on May 12, 2022

Project Type: In-Lieu Recharge

Water Source: The surface water source of this project is from SEWD's existing contract with the U.S. Bureau of Reclamation (USBR) for the New Hogan Reservoir. Surface water is diverted from the Calaveras River. This is an existing surface water right.

Delivery Area: Approximately 1,750 acres of orchards surrounding Lake Grupe in SEWD

Project Overview: The Lake Grupe In-Lieu Recharge Project, proposed by SEWD, is to construct a surface water diversion turn-out on the Calaveras River, upstream of Bellota, and to supply surface water to multiple farms/growers currently using groundwater. The project is to allow about 1,750 acres of orchard crops to irrigate with surface water from Lake Grupe instead of using groundwater. The project would pump water from the Calaveras River and transport to Lake Grupe via a pipeline, and then the surrounding growers would pump the water from the Lake for irrigation. The benefit of this project is the in-lieu banking of groundwater from irrigation conversion with very little losses assumed in the transport and delivery of the water. This project is currently in construction and should be operational in 2022.

Project Volume:

Since the water is transported by a pipeline to Lake Grupe, no evaporation or seepage losses are assumed to occur between Calaveras River and Lake Grupe. The volume of water delivered was assumed by multiplying 1,750 acres by an assumed 2.8 acre-feet per acre per year (AF/AY). In situations where there are multiple dry years, the range of water expected is from 0 to 2,000 AFY. Because the baseline water year type Drought represents strings of dry years (water years that were actually part of drought periods), multiple dry years are captured in the Drought deliveries and were assumed to be 2,000 AFY.

Baseline Water Year Type	Annual Volume (acre-feet per year or AFY)	Notes
Drought	2,000	Range of 0-2,000 AFY in multiple drought years
Dry	4,900	
Normal	4,900	
Wet	4,900	

2.2 SEWD Surface Water Implementation Expansion

Submitting GSA: Stockton East Water District (SEWD)

Project Source: GSP Project #2 (Chapter 6.2.4.2) and personal communication with Scot Moody (SEWD) and Justin Hopkins (SEWD) on April 21, 2022

Project Assumptions Confirmed By: Justin Hopkins (SEWD) on May 9, 2022 and Jeanne Zolezzi (Herum\Crabtree\Suntag) on May 12, 2022

Project Type: In-Lieu Recharge

Water Source: This project relies on water from New Hogan Reservoir (Calaveras River water) and New Melones Reservoir (Stanislaus River water). This is an existing surface water right. SEWD has long-term water supply contracts with USBR for both New Hogan Reservoir and New Melones Reservoir.

Delivery Area: Approximately 6,750 acres adjacent to surface water conveyance systems in SEWD

Project Overview: As part of the SEWD Surface Water Implementation Expansion Project, SEWD would require landowners adjacent to surface water conveyance systems (rivers or pipelines) to utilize surface water as part of the SGMA implementation. This would increase surface water usage by about 18,000 to 20,000 AF/year with in-lieu groundwater recharge benefits. Currently, there are about 6,000 acres irrigated with groundwater that could be converted to surface water. There are also an additional 1,500 acres with inactive surface water accounts. SEWD would be the lead agency in environmental/CEQA review and would assist landowners/growers in establishing a turnout for agricultural irrigation and acquiring necessary permits through federal and state regulatory agencies. SEWD has completed the conversion of 153 acres to surface water, is in the construction phase to convert an additional 2,592 acres, and in the planning phase to convert an additional 1,048 acres.

Project Volume:

Estimated evaporation and seepage losses occurring between Calaveras River or Stanislaus River and SEWD land are incorporated in a separate diversion in ESJWRM. As a conservative estimate, no additional seepage is assumed to occur due to the transport and delivery of this water. The volume of water delivered was estimated by multiplying an estimated 6,750 acres (average of 6,000 and 7,500 acres) by an assumed 2.8 AF/AY and rounding to the nearest thousand. In situations where there are multiple dry years, the range of water expected is from 0 to 4,000 acre-feet per year (AFY). Because the baseline water year type Drought represents strings of dry years (water years that were actually part of drought periods), multiple dry years are captured in the Drought deliveries and were assumed to be 4,000 AFY.

Baseline Water Year Type	Annual Volume (acre-feet per year or AFY)	Notes
Drought	4,000	Range of 0-4,000 AFY in multiple drought years
Dry	8,000	
Normal	19,000	
Wet	19,000	

2.3 West Groundwater Recharge Basin

Submitting GSA: Stockton East Water District (SEWD)

Project Source: Project not included in GSP. Added based on information provided by personal communication with Scot Moody (SEWD) and Justin Hopkins (SEWD) on April 21, 2022.

Project Assumptions Confirmed By: Justin Hopkins (SEWD) on May 9, 2022

Project Type: Direct Recharge

Water Source: This project relies on water from New Hogan Reservoir (Calaveras River water) and New Melones Reservoir (Stanislaus River water). This is an existing surface water right. SEWD has long-term water supply contracts with USBR for both New Hogan Reservoir and New Melones Reservoir. In addition to Calaveras River and Stanislaus River water, stormwater runoff will also contribute to the volume of water available for recharge.

Delivery Area: Recharge basin near SEWD water treatment plant

Project Overview: The United States Army Corps of Engineers (ACOE) plans to excavate dirt to use for levees near the Dr. Joe Waidhofer Water Treatment Plant operated by SEWD. SEWD will use this estimated 100-acre pit once it is created for a new groundwater recharge basin. The recharge at the site was estimated to be about 0.5 feet per day. The project is currently in the design stage with first phase construction beginning summer 2022 and is estimated to be completed in approximately 2032.

Project Volume:

Due to the varying sources of water (surface water and stormwater runoff), the project is expected to be able to recharge project year-round.

Baseline Water Year Type	Annual Volume (acre-feet per year or AFY)	Notes
Drought	1,500	
Dry	4,000	
Normal	16,000	
Wet	16,000	

2.4 CSJWCD Capital improvement Program

Submitting GSA: Central San Joaquin Water Conservation District (CSJWCD)

Project Source: GSP Project #6 (Chapter 6.2.4.6) and personal communication with Reid Roberts (CSJWCD) on April 26, 2022

Project Assumptions Confirmed By: Reid Roberts (CSJWCD) on May 6, 2022

Project Type: In-Lieu Recharge

Water Source: This project relies on water from New Melones Reservoir. This is an existing surface water right. CSJWCD has long-term water supply contracts with USBR for the New Melones Unit Central Valley Project.

Delivery Area: CSJWCD

Project Overview: CSJWCD assists users to convert groundwater-irrigated fields to surface water use. The user applies for water credits based upon new surface water acres. The user is responsible for constructing a diversion facility. As water is diverted, the district reduces the water charge until credit is used or seven years since implementation have elapsed. A poll conducted prior to any surface water delivery within the district estimated between 25,000 to 30,000 acres could be brought onto surface water supply. The Capital Improvement Program has been on-going since 1996 and new individual projects are anticipated to begin each year with CSJWCD Board approval and possible streambed alteration permits. Currently, the District takes between 35,000 to 40,000 AFY of its surface water contract to irrigate approximately 15,000 acres. The district has identified an additional 10,000 to 15,000 acres for ongoing expansion of the Capital Improvement Program.

Project Volume:

CSJWCD has a contract with USBR for up to 80,000 AFY of Stanislaus River water with a firm yield of 49,000 AFY. In exceptionally dry years (DWR critical years), the district's allotment is zero. An agreement with City of Stockton gives SEWD the first 15,000 AFY for M&I, so the least CSJWCD is expected to receive in Dry years is 34,000 AFY (49,000 AF – 15,000 AF).

Conservatively, a total of 2 AF/acre was assumed to account for variable water use amounts among different crop types. For Normal and Wet years, an estimated 12,000 acres (assuming a rounded average of the estimated 10,000 to 15,000 acres identified for surface water) were used with the assumed 2 AF/acre water use to determine the annual volume of 24,000 AFY. Considering the District's firm yield, Dry years are assumed to yield 12,000 AFY as the difference between the existing amount CSJWCD is estimated to receive already in ESJWRM and the 34,000 AFY total the district can expect to receive at minimum.

CSJWCD's surface water diversions lose about an estimated 25-30% of the water on the way to being delivered. This amount will be applied to the diversion in ESJWRM for the calculation of losses due to evaporation and seepage.

Baseline Water Year Type	Annual Volume (acre-feet per year or AFY)	Notes
Drought	0	
Dry	12,000	
Normal	24,000	
Wet	24,000	

2.5 Long-term Water Transfer to SEWD and CSJWCD

Submitting GSA: South San Joaquin GSA

Project Source: GSP Project #8 (Chapter 6.2.4.8) and personal communication with Justin Hopkins (SEWD), Eric Thorburn (Oakdale Irrigation District or OID), Reid Roberts (CSJWCD), and Brandon Nakagawa (South San Joaquin Irrigation District or SSJID) on April 25, 2022.

Project Assumptions Confirmed By: Justin Hopkins (SEWD) on May 9, 2022 and Emily Sheldon (Oakdale Irrigation District or OID) on May 9, 2022

Project Type: Transfers/In-Lieu Recharge

Water Source: This project relies on water from New Melones Reservoir (Stanislaus River water). This is an existing surface water right (pre-1914) held by Oakdale Irrigation District (OID) and South San Joaquin Irrigation District (SSJID).

Delivery Area: SEWD and CSJWCD

Project Overview: OID and SSJID have historically participated in long-term water transfers of surplus and pre-1914 surface water rights to other entities in the Eastern San Joaquin Subbasin. These transfers have included one-year transfers to CSJWCD as well as a nearly 10-year transfer to SEWD for both agricultural and urban purposes. CSJWCD and SEWD both have surface water available from the USBR's Central Valley Project on the Stanislaus River; however, project water allocations have become significantly reduced in DWR water year types of below normal and dry years, resulting in increased groundwater reliance to meet annual and permanent crop water demands. Providing long-term water transfers from OID/SSJID to other agencies within ESJ Subbasin would allow for increased average annual surface water deliveries to the Subbasin, reducing groundwater reliance and overdraft within the Subbasin. SEWD and CSJWCD overlie a significant portion of the Subbasin dependent on groundwater and subject to historical overdraft conditions.

No new facilities need to be constructed for this project. Historical transfers have been accomplished through existing facilities, including a tunnel just upstream of the OID/SSJID-owned Goodwin Dam on the Stanislaus River. Additional infrastructure may be necessary to increase distribution of surface water supplies to irrigated agriculture and to achieve adequate improvement toward sustainability goals.

Project funding could be provided directly from the districts participating in water transfers. Additional infrastructure to promote surface water use and capital payments for surface water transfers could be provided indirectly by groundwater reliant entities, thereby providing a means of continuing to utilize groundwater while investing in a Subbasin-wide project that assures continued sustainability within the Subbasin.

Project Volume:

The amount and use of the transferred water may vary widely, as SEWD may utilize the supply for either municipal and industrial (M&I) deliveries to Stockton area urban contractors or agricultural customers in SEWD's district boundaries, while CSJWCD may use the supply for agricultural customers in CSJWCD's district boundaries. Due to CSJWCD's firm supply of 49,000 AFY from its New Melones water right and the expansion of surface water use within the District through the Category A project "CSJWCD Capital Improvement Program", the district is not expected to require additional surface water via water transfer for agricultural customers within the district boundaries. SEWD also has no plans to take transferred water for agricultural purposes due to its Category A "SEWD Surface Water Implementation Expansion."

SEWD expects to receive water from its own water sources during wet and normal years, so transfers of water from SSJID and OID are only expected to occur in critical and dry water years. SEWD has an agreement with the Stockton area urban contractors that a minimum of 20,000 AFY must be supplied for M&I purposes. The first 15,000 AFY of CSJWCD's 49,000 AFY allocation is provided to SEWD via an agreement between the districts. In critical years, when CSJWCD's supply is also zero, SEWD plans to take 20,000 AFY via transferred water to fulfill its urban agreement and 5,000 AFY of transferred water in dry years when 15,000 AFY is available from CSJWCD's supply.

This project currently only covers the transfer of water from OID and SSJID to SEWD urban customers. Both OID and SSJID may transfer water for agricultural purposes to SEWD and CSJWCD or to other out-of-district users in the future as opportunities arise.

Baseline Water Year Type	**Annual Volume (acre-feet per year or AFY)**		**Notes**
	M&I to SEWD to Urban Contractors	**Agricultural**	
Drought	20,000	0 (both SEWD and CSJWCD)	
Dry	5,000	0 (both SEWD and CSJWCD)	
Normal	0	0 (both SEWD and CSJWCD)	
Wet	0	0 (both SEWD and CSJWCD)	

2.6 White Slough Water Pollution Control Facility Expansion

Submitting GSA: City of Lodi

Project Source: GSP Project #5 (Chapter 6.2.4.5) and personal communication with Travis Kahrs and Charles Swimley (City of Lodi) on April 25, 2022

Project Assumptions Confirmed By: Travis Kahrs (City of Lodi) on May 11, 2022

Project Type: Recycled Water/In-Lieu Recharge

Water Source: Treated wastewater effluent from White Slough Water Pollution Control Facility

Delivery Area: 70-acre pond with capacity of 388 AF and 890 acres of agricultural land surrounding White Slough Pollution Control Facility

Project Overview: This project includes the construction of a 70-acre pond expansion with a storage capacity of 388 AF. The purpose of this project is to provide tertiary-treated Title 22 effluent for use as irrigation water on approximately 890 acres of agricultural land used to grow crops for dairy cattle, such as corn, wheat, and alfalfa surrounding the White Slough Water Pollution Control Facility (WPCF) to offset groundwater pumping. This project is estimated to reduce the annual volume discharged to Dredger Cut (a dead-end slough of the Sacramento-San Joaquin River Delta) by approximately 160 to 210 million gallons. Flow will be diverted from Dredger Cut at a rate up to 1,700 gallons per minute over an approximate 75- to 90-day period between October 1 and May 31 of each year. Project studies have demonstrated that the storage provided by this project will significantly offset groundwater pumping through in-lieu use. This project is completed and fully online.

Project Volume:

The project is able to store and recharge project year-round due to constant operations of the WPCF. The irrigation season is generally mid-April through September, during which water is provided to 790 acres of agricultural land. In 2020, per the City of Lodi's 2020 Urban Water Management Plan[1], the city used a total of 3,729 AF for agricultural irrigation, with projected volumes to remain the same through at least 2045. Based on a preliminary Surface Pond Percolation Study[2] (completed by Petralogix in 2016), the unlined ponds were anticipated to have an annual percolation to groundwater rate of up to 29 to 51 million gallons per year or approximately 100 to 200 AFY. With 3,729 AFY expected to be used for agricultural irrigation in the future, the amount of percolation is estimated to be about 4% of this amount or about 150 AFY.

Baseline Water Year Type	**Annual Volume (acre-feet per year or AFY)**	**Notes**
Drought	3,729	
Dry	3,729	
Normal	3,729	
Wet	3,729	

2.7 NSJWCD South System Modernization

Submitting GSA: North San Joaquin Water Conservation District (NSJWCD)

Project Source: GSP Project #7 (Chapter 6.2.4.7) and personal communication with Jennifer Spaletta (Spaletta Law PC) and Daniel de Graaf (de Graaf Engineering) on April 18, 2022

---

[1] City of Lodi, 2021. 2020 Urban Water Management Plan. August 2021.

[2] Petralogix, 2016. City of Lodi Surface Pond Percolation Report. September 23, 2016.

Project Assumptions Confirmed By: Jennifer Spaletta (Spaletta Law PC) on May 4, 2022

Project Type: In-Lieu Recharge/Direct Recharge

Water Source: This project relies on water from the Mokelumne River. This is an existing water right held by NSJWCD (Permit 10477).

Delivery Area: NSJWCD South System

Project Overview: This project will modernize the South System Pump and Distribution System to facilitate delivery of additional surface water to farmers in-lieu of groundwater pumping. Water would come from NSJWCD Permit 10477 supplies, which are available in about 55 percent of years. Environmental review for the project is complete and funding has been sought and a landowner improvement district has been formed.

Project Volume:

The volumes for the project tabulated below were provided by Jennifer Spaletta on April 21, 2022 and cover both the NSJWCD South System Modernization as well as the NSJWCD Tecklenburg Recharge Project. In wet and normal years, about 50% of the water will be used for agricultural purposes and 50% for recharge (likely via the Tecklenburg Recharge Project). In critical years, no water is available and in dry years, all of the water is expected to be used for recharge projects. Based on these assumptions, the water was split into the two projects in the table below. The project is expected to be 50% built out by 2028 and fully built out by 2035.

The volumes below assume NSJWCD uses its full water right of 20,000 AFY between all of its projects in wet years, 80% of the 20,000 AFY or 16,000 AFY in normal years, and very limited quantities in dry years. Appendix A includes the numbers provided by Jennifer Spaletta, which also includes edits to the existing CAL FED groundwater recharge project and the Tracy Lake recharge project as part of NSJWCD utilizing more of its existing water right.

Baseline Water Year Type	**Annual Volume (acre-feet per year or AFY)**			**Notes**
	Total South System Modernization and Tecklenburg Recharge Project	**South System Modernization**	**Tecklenburg Recharge Project**	
Drought	0	0	0	
Dry	1,000	0	1,000	
Normal	9,600	4,800	4,800	
Wet	12,000	6,000	6,000	

2.8 NSJWCD Tecklenburg Recharge Project

Submitting GSA: North San Joaquin Water Conservation District (NSJWCD)

Project Source: GSP Project #14 (Chapter 6.2.5.6) and personal communication with Jennifer Spaletta (Spaletta Law PC) and Daniel de Graaf (de Graaf Engineering) on April 18, 2022

Project Assumptions Confirmed By: Jennifer Spaletta (Spaletta Law PC) on May 4, 2022

Project Type: Direct Recharge

Water Source: This project relies on water from the Mokelumne River. This is an existing surface water right held by NSJWCD (Permit 10477).

Delivery Area: NSJWCD South System

Project Overview: NSJWCD is investigating constructing and operating a 10-acre recharge pond on the south side of the Mokelumne River on property owned by the Tecklenburg family through a purchase. NSJWCD would use Permit 10477 water available during December 1 through June 30, and not needed for irrigation, for recharge. Because this project can use water available during the direct diversion flood season, water is expected to be available more frequently under the NSJWCD water right for this project, or 80 percent of years.

Project Volume:

The volumes for the project tabulated below were provided by Jennifer Spaletta on April 21, 2022 and cover both the NSJWCD South System Modernization as well as the NSJWCD Tecklenburg Recharge Project. In wet and normal years, about 50% of the water will be used for agricultural purposes and 50% for recharge (likely via the Tecklenburg Recharge Project). In critical years, no water is available and in dry years, all of the water is expected to be used for recharge projects. Based on these assumptions, the water was split into the two projects in the table below. The project is expected to be 50% built out by 2028 and fully built out by 2035.

The volumes below assume NSJWCD uses its full water right of 20,000 AFY between all of its projects in wet years, 80% of the 20,000 AFY or 16,000 AFY in normal years, and very limited quantities in dry years. Appendix A includes the numbers provided by Jennifer Spaletta, which also includes edits to the existing CAL FED groundwater recharge project and the Tracy Lake recharge project as part of NSJWCD utilizing more of its existing water right.

Baseline Water Year Type	Annual Volume (acre-feet per year or AFY)			Notes
	Total South System Modernization and Tecklenburg Recharge Project	South System Modernization	Tecklenburg Recharge Project	
Drought	0	0	0	
Dry	1,000	0	1,000	
Normal	9,600	4,800	4,800	
Wet	12,000	6,000	6,000	

2.9 NSJWCD South System Groundwater Banking with EBMUD

Submitting GSA: North San Joaquin Water Conservation District (NSJWCD)

Project Source: GSP Project #11 (Chapter 6.2.5.3) and personal communication with Jennifer Spaletta (Spaletta Law PC) and Daniel de Graaf (de Graaf Engineering) on April 18, 2022

Project Assumptions Confirmed By: Jennifer Spaletta (Spaletta Law PC) on May 4, 2022

Project Type: In-Lieu Recharge

Water Source: This project relies on water from the Mokelumne River. This is an existing water right held by East Bay Municipal Utility District (EBMUD) (Permit 10478) as per Protest Dismissal Agreement from 11/25/2014.

Delivery Area: NSJWCD South System

Project Overview: NSJWCD, EBMUD, and other entities in San Joaquin County entered into a Protest Dismissal Agreement in 2014 (the "PDA") to resolve various water rights protests. The PDA Agreement includes a commitment to undertake a pilot-level groundwater banking project and a longer-term groundwater baking project. The pilot level banking project is called the "DREAM" project and is already underway. The DREAM project involves the delivery of 1,000 AF of EBMUD water into the NSJWCD service area along the South System to use for irrigation, effectuating 1,000 AF of in-lieu groundwater recharge. EBMUD will receive a banked water credit of 50 percent of the amount of water recharge, not to exceed 500 AF. EBMUD can withdraw the banked water credit in the future. NSJWCD will control the withdrawal of the banked water by pumping groundwater from a well that is centrally located in the area of recharge and then conveying the pumped groundwater to the EBMUD Mokelumne Aqueduct. The extraction and return of the banked water are subject to a San Joaquin County groundwater export permit. The permit places additional conditions and restrictions on the extraction of the banked water, including a 5 percent per year annual loss factor and pumping restrictions to prevent impacts to other groundwater users.

EBMUD and NSJWCD have started the preliminary planning for the longer-term banking project. The longer-term banking project may use the same concept as the pilot project but will involve larger quantities of water and potential additional facilities to deliver and use the water for in-lieu recharge within NSJWCD, and to extract and return banked water credits to EBMUD. These surface water supplies would come from EBMUD's water rights on the Mokelumne River and would be in addition to surface water available under NSJWCD's water right. EBMUD would receive a banked water credit for 50 percent of all additional supplies provided. The net water gain to NSJWCD may increase if EBMUD does not extract its banked supplies regularly because of the 5 percent annual loss factor in the San Joaquin County export ordinance.

The PDA also provides that the wet year water supplies could be used by SEWD for groundwater banking if they cannot be used in NSJWCD.

Project Volume:

The volumes for the project tabulated below were provided by Jennifer Spaletta on April 21, 2022. In wet and normal years, about 50% of the water will be used for agricultural purposes and 50% for recharge. In critical years, no water is available and in dry years, all of the water is expected to be used for recharge projects. An agreement is in place and parties need finalize design. Environmental review and permitting are still needed. NSJWCD and EBMUD are currently working to complete the pilot DREAM project. Facilities to complete the final phases of the pilot project are currently under construction and are expected to be completed by early 2022. Planning efforts for a larger scale banking project are underway. The project is expected to be 50% built out by 2028 and fully built out by 2035. EBMUD will receive a banked water credit of 50% of amount recharged, not to exceed 500 AF.

Appendix A includes the numbers provided by Jennifer Spaletta, which also includes edits to the existing CAL FED groundwater recharge project and the Tracy Lake recharge project as part of NSJWCD utilizing more of its existing water right.

Baseline Water Year Type	Annual Volume (acre-feet per year or AFY)	Notes
Drought	0	
Dry	1,500	
Normal	6,400	80% of Wet year supply
Wet	8,000	

2.10 NSJWCD North System Modernization/Lakso Recharge

Submitting GSA: North San Joaquin Water Conservation District (NSJWCD)

Project Source: GSP Project #12 (Chapter 6.2.5.4), 2022 SGM Implementation Grant Program Round 1 application, and personal communication with Jennifer Spaletta (Spaletta Law PC) and Daniel de Graaf (de Graaf Engineering) on April 18, 2022

Project Assumptions Confirmed By: Jennifer Spaletta (Spaletta Law PC) on May 4, 2022

Project Type: In-Lieu Recharge/Direct Recharge

Water Source: This project relies on water from the Mokelumne River. This is an existing surface water right held by NSJWCD (Permit 10477).

Delivery Area: NSJWCD North System

Project Overview: This project will repair, upgrade, and modernize the North System Pump and Distribution System to facilitate delivery of surface water to farmers in-lieu of groundwater pumping and surface water for direct and Flood MAR recharge in the non-irrigation season. Water would come from NSJWCD Permit 10477 supplies, which are available in about 55 percent of years. The Lakso vineyard is located along the existing North System pipeline and includes very sandy soils that are excellent for recharge. The Lakso recharge project involves using a portion of this vineyard for direct recharge and/or Flood MAR. Flood MAR operations could be expanded to additional vineyards and orchards along the North System pipeline.

This project received a 2022 SGMA Implementation Round 1 grant for $3.9 million. Project construction is anticipated to be complete by March 2025.

Project Volume:

The volumes for the project tabulated below were provided by Jennifer Spaletta on April 21, 2022. In wet and normal years, about 50% of the water will be used for agricultural purposes and 50% for recharge (likely via the Lakso Recharge Project). In critical years, no water is available and in dry years, all of the water is expected to be used for recharge projects. The project is expected to be 50% built out by 2028 and fully built out by 2035.

The volumes below assume NSJWCD uses its full water right of 20,000 AFY between all of its projects in wet years, 80% of the 20,000 AFY or 16,000 AFY in normal years, and very limited quantities in dry years. Appendix A includes the numbers provided by Jennifer Spaletta, which also includes edits to the existing CAL FED groundwater recharge project and the Tracy Lake recharge project as part of NSJWCD utilizing more of its existing water right.

Baseline Water Year Type	Annual Volume (acre-feet per year or AFY)	Notes
Drought	0	
Dry	1,000	
Normal	3,200	
Wet	4,000	

2.11 Delta Water Treatment Plant Groundwater Recharge Improvements Project Geotechnical Investigation

Submitting GSA: City of Stockton

Project Source: GSP Project #20 (Chapter 6.2.6.3), 2022 SGM Implementation Grant Program Round 1 application, and personal communication with Mel Lytle (City of Stockton), Eric Houston (City of Stockton), and Mitchell Maidrand (City of Stockton) on April 21, 2022

Project Assumptions Confirmed By: Received no response to draft assumptions sent out on May 3, 2022 and May 24, 2022

Project Type: Direct Recharge

Water Source: Delta Water Treatment Plant

Delivery Area: Recharge basin adjacent to Delta Water Treatment Plant (approximately 70 acres of ponds at buildout in 2040)

Project Overview: The City of Stockton – Municipal Utilities Department (MUD) commissioned the Delta Water Supply Project (DWSP) in 2012 to provide a supplemental surface water supply to its customers. The project included a river diversion pumping station, 12 miles of 54-inch raw water pipeline, a 30 million gallon per day water treatment plant, and six miles of finished water pipelines. This project, located on approximately 60 acres of a larger 130-acre parcel on Lower Sacramento Road, was designed, in part, to protect the groundwater basin through conjunctive management to improve the City's water supply reliability portfolio.

The original Draft Environmental Impact Report (2005) programmatically evaluated the concept of an Aquifer Storage and Recovery (ASR) project as part of a long-term water resource planning effort for the City. During the design phase, MUD commissioned the Design-Build team to conduct a preliminary groundwater recharge feasibility study of the approximate 70-acre site adjacent to the Delta Water Treatment Plant (DWTP). This study concluded that with available water from the City's Delta diversion and from Woodbridge Irrigation District, a direct groundwater recharge and recovery project was feasible and recommended additional engineering feasibility and design studies to confirm water availability, recharge infiltration rates, and storage capabilities. The draft study, completed in 2009, is now focused on further evaluation beginning with geotechnical and hydrogeologic effort and groundwater feasibility report to inform a future project phase of implementing a groundwater recharge and recovery project.

The City is considering the completion of an Underground Storage Supplement through the State Water Resources Control Board for Water Right Permit 21176. Pipeline infrastructure and turnouts will be needed to convey Delta water, diverted under Permit 21176, from the incoming Intake Pump Station 54-inch raw water line to the proposed recharge basin location at the Delta Water Treatment Plant.

This project received a 2022 SGMA Implementation Round 1 grant for $250,000 to conduct a geotechnical investigation of the recharge site to determine the suitability of the site for groundwater recharge and recovery.

Project Volume:

A feasibility memorandum completed in 2009[1] estimated that Mokelumne River water purchased from WID as well as City of Lodi stormwater available from the Wilkerson Lateral could be utilized for recharge purposes. An estimated amount of up to 6,500 AFY between March 1 and October 15 would be available from WID, with water assumed to be available only during water year types that are "Wet" or "Above Normal." Additionally, Lodi stormwater is a potential source for groundwater recharge and an estimated 1,545 AFY is available mostly during winter months when precipitation occurs. The estimated recharge rate at the site was 0.8 AF/day.

In order to expand the use of Permit 21176 water, City of Stockton's water supply from the San Joaquin River could also be utilized. With an assumed infiltration pond size of 70 acres and a wetted period of 228 days, an estimated 12,768 AFY could potentially be stored to the groundwater basin. Though if water was available during only a 90-day application period, the potential recharge volume would be 5,040 AFY. In the City of Stockton's water rights petition[2], an annual total of 5,102 AFY was estimated to be available for groundwater banking with zero in April through June. Though this project has been called groundwater banking in the past, there are no firm plans to extract water and no more water would be extracted than was recharged. A more detailed technical analysis of the timing and quantity of water supply will be conducted in the future.

In order to be conservative in the estimation of the project's recharge potential, the lower estimate of 5,040 AFY was assumed. Due to the varying sources of water supply that may be available for recharge (WID water, Lodi stormwater, and Stockton water), water is expected to be able to be recharged year-round.

Baseline Water Year Type	Annual Volume (acre-feet per year or AFY)	Notes
Drought	5,040	
Dry	5,040	
Normal	5,040	
Wet	5,040	

3. Results of Category A Projects in ESJWRM

This section provides a summary of the ESJ Subbasin ESJWRM Projected Condition BaseLine with Category A Projects and Management Actions (PCBL-PMA) and Projected Condition BaseLine with Climate Change and Category A Projects and Management Actions (PCBL-CC-PMA) model results.

---

[1] Swann, B. and Heywood, B., 2009. Draft Memorandum Groundwater Recharge Program Evaluation. March 24, 2009.

[2] City of Stockton Water Right Permit 21176 Petition for Extension of Time

Both models share the same input files, excepting those files related to climate change (stream inflows, evapotranspiration, and precipitation). The files relating to the Category A projects simulated as new surface water diversions are identical between the two models. Any differences in the amount of water delivered in the two models are due to differences in agricultural demand and the amount of water available in streams. A summary of the 11 Category A PMAs simulated as additional diversions in both PCBL-PMA and PCBL-CC-PMA models is provided in Table 1, along with fractions for recoverable loss (i.e., percolation or canal seepage), non-recoverable loss (i.e., evaporation), and delivery (i.e., amount delivered is equal to the total amount minus the recoverable and non-recoverable losses). The remaining 66 PCBL and PCBL-CC diversions are summarized in a separate document (Woodard & Curran, 2022).

Table 1: Summary of ESJWRM Category A Projects Surface Water Deliveries

ID	Description	Diversion Location	Delivery Area	Primary Use	Fraction			Average Annual Diversion*** (acre-feet)
					RL*	NL**	Delivery	
67	Stockton East WD Lake Grupe In-Lieu Recharge	Calaveras River	Approximately 1,750 acres of orchards surrounding Lake Grupe in SEWD	Ag	0%	0%	100%	4,300
68	Stockton East WD Surface Water Implementation Expansion	Import (outside of ESJWRM)	Approximately 6,750 acres adjacent to surface water conveyance systems in SEWD	Ag	0%	0%	100%	13,400
69	Stockton East WD West Groundwater Recharge Basin	Import (outside of ESJWRM)	Recharge basin near SEWD water treatment plant	Recharge	100%	0%	0%	10,200
70	Central San Joaquin WCD Capital improvement Program	Import (outside of ESJWRM)	CSJWCD	Ag	15%	2%	83%	20,300
71	Long-term Water Transfer to Stockton East WD for M&I	Import (outside of ESJWRM)	City of Stockton area urban users	Urban	0%	0%	100%	11,500
72	City of Lodi White Slough Water Pollution Control Facility Expansion	Import (outside of ESJWRM)	890 acres of agricultural land surrounding White Slough Pollution Control Facility	Ag	4%	2%	100%	3,700
73	North San Joaquin WCD South System Modernization	Mokelumne River	NSJWCD South System	Ag	50%	0%	50%	5,500

ID	Description	Diversion Location	Delivery Area	Primary Use	Fraction			Average Annual Diversion*** (acre-feet)
					RL*	NL**	Delivery	
74	North San Joaquin WCD Tecklenburg Recharge Project	Mokelumne River	Recharge basin located in NSJWCD South System	Recharge	100%	0%	0%	4,100
75	North San Joaquin WCD South System Groundwater Banking with EBMUD	Mokelumne River	NSJWCD South System	Ag	50%	0%	50%	5,600
76	North San Joaquin WCD North System Modernization/Lasko Recharge	Mokelumne River	NSJWCD North System	Ag	50%	0%	50%	2,600
77	City of Stockton Delta Water Treatment Plant Groundwater Recharge Improvements Project Geotechnical Investigation	Import (outside of ESJWRM)	Recharge basin adjacent to Delta Water Treatment Plant	Recharge	100%	0%	0%	5,000

*RL = Recoverable Loss (canal seepage or recharge)

**NL = Non-Recoverable Loss (evaporation)

*** Averages calculated only for years with diversions occurring (i.e., non-zero average)

3.1 Projected Conditions Baseline with Category A Projects and Management Actions

The section below summarizes the results for the PCBL-PMA as compared to the PCBL. Neither of these runs include climate change.

3.1.1 Land and Water Use Water Budget

The land and water use budget includes two different versions, agricultural and urban, and represents the balance of the model-calculated water demands with the water supplied. Both the agricultural and urban versions include the same components that make up the water balance:

- Inflows:
    - Groundwater pumping
    - Surface water deliveries
    - Shortage (if applicable)
- Outflows:
    - Demand (either agricultural or urban)
    - Surplus (if applicable)

The average annual PCBL-PMA water demand for the Subbasin within the 52-year simulation period is 1,256,100 acre-feet per year (AFY), consisting of approximately 1,098,000 AFY of agricultural demand and 158,100 AFY of urban demand. This demand is met by an annual average of 571,100 AFY of surface water deliveries (490,400 AFY of agricultural and 80,700 AFY of urban deliveries) and is supplemented by 704,400 AFY of groundwater production (627,200 AFY of agricultural and 77,200 AFY of urban pumping). Due to uncertainties in the estimation of projected agricultural demand and historical supply records, there is 19,600 AFY of surplus in the Subbasin-scale agricultural water supply, which is insignificant relative to the total volume of water use. Shortage and surplus represent a misalignment between the reported, estimated, or assumed water supply (groundwater pumping and surface water deliveries) and the calculated demands. In the projected conditions, there are uncertainties in the assumptions and parameters used for both monthly supply and demand estimates and/or calculations, resulting in misalignments, which is reported as shortage or surplus. These annual averages are shown in Table 2. The annual land and water use budgets across the ESJ Subbasin are shown in Figure 2**Error! Reference source not found.** and **Error! Reference source not found.** for the Subbasin as a whole, showing the agricultural and urban, respectively, demands plotted with water supplies.

Table 2 also includes the PCBL results and a Category A projects benefit calculated as the PCBL-PMA results minus the PCBL results. The PCBL-PMA has an average of 37,600 AFY more surface water for agricultural purposes and 5,100 AFY more surface water for urban areas compared to the PCBL. For urban areas, this represents a comparable reduction in groundwater pumping of 5,000 AFY. For agricultural areas, the increased surface water results in 33,400 AFY less groundwater pumping, a number smaller than the amount of surface water provided due to a mismatch between the Category A water supplied and model-calculated agricultural demand on a monthly basis.

Table 2: Eastern San Joaquin Subbasin Land and Water Use Budget Annual Average Comparison Between the PCBL (Version 2.0) and the PCBL-PMA

Land and Water Use Budget Component	Annual Average		
	PCBL (Version 2.0)	PCBL-PMA	PMA Benefit (PCBL-PMA minus PCBL)
Agricultural Area (thousand acres)	359	359	0
Agricultural Demand (AFY)	1,099,900	1,098,000	-1,900
Agricultural Groundwater Pumping (AFY)	660,600	627,200	-33,400
Agricultural Surface Water Deliveries (AFY)	452,800	490,400	37,600
Agricultural Shortage (AFY)[1]	-13,500	-19,600	-6,100
Urban Area (thousand acres)	153	153	0
Urban Demand (AFY)	158,100	158,100	0
Urban Groundwater Pumping (AFY)	82,200	77,200	-5,000
Urban Surface Water Deliveries (AFY)	75,600	80,700	5,100
Urban Shortage (AFY)[1]	300	200	-100

---

[1] Shortage and surplus represent a misalignment between the reported, estimated or assumed water supply (groundwater pumping and surface water deliveries) and the calculated demands. In the historical model, this can occur when there are inaccuracies in the reported water supplies or uncertainties in the methodology and/or parameters used to calculate the demand. In the projected conditions, there are uncertainties in the assumptions and parameters used for both monthly supply and demand estimates and/or calculations, resulting in misalignments, which is reported as shortage or surplus.

Figure 2: Eastern San Joaquin Subbasin Projected Agricultural Demand in the PCBL-PMA

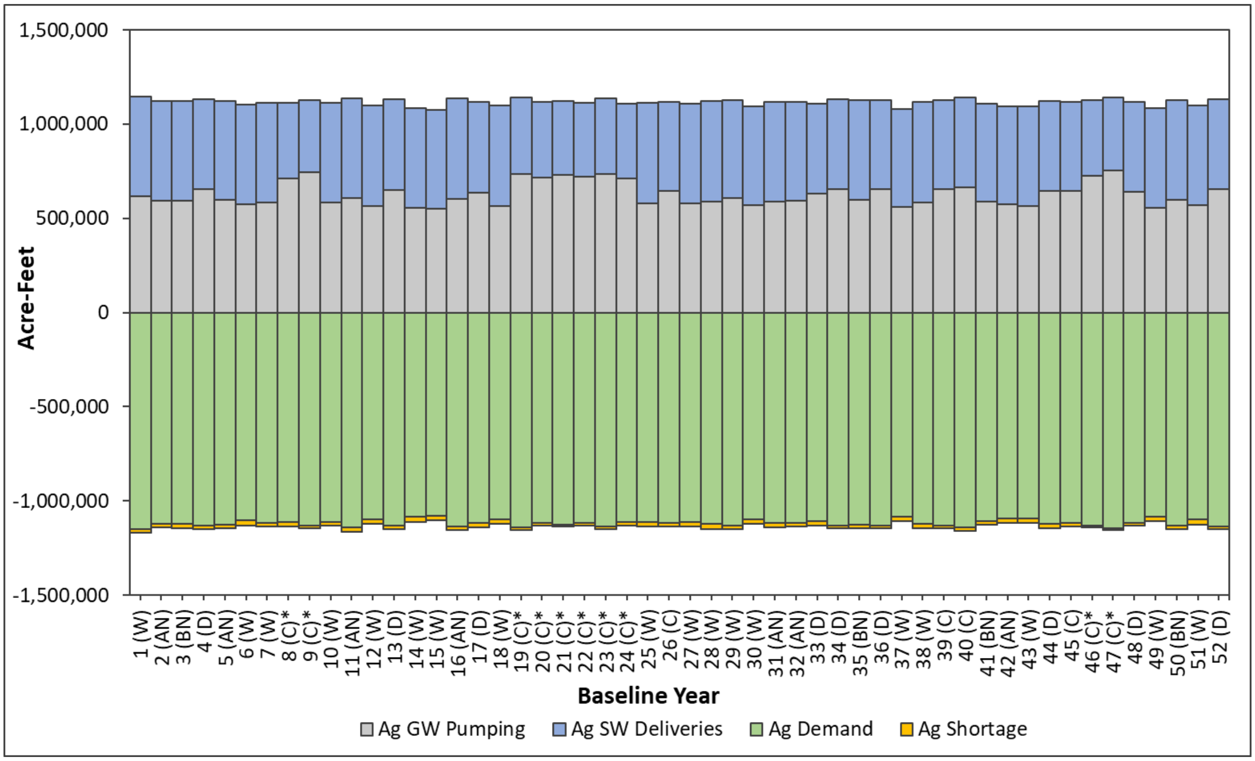
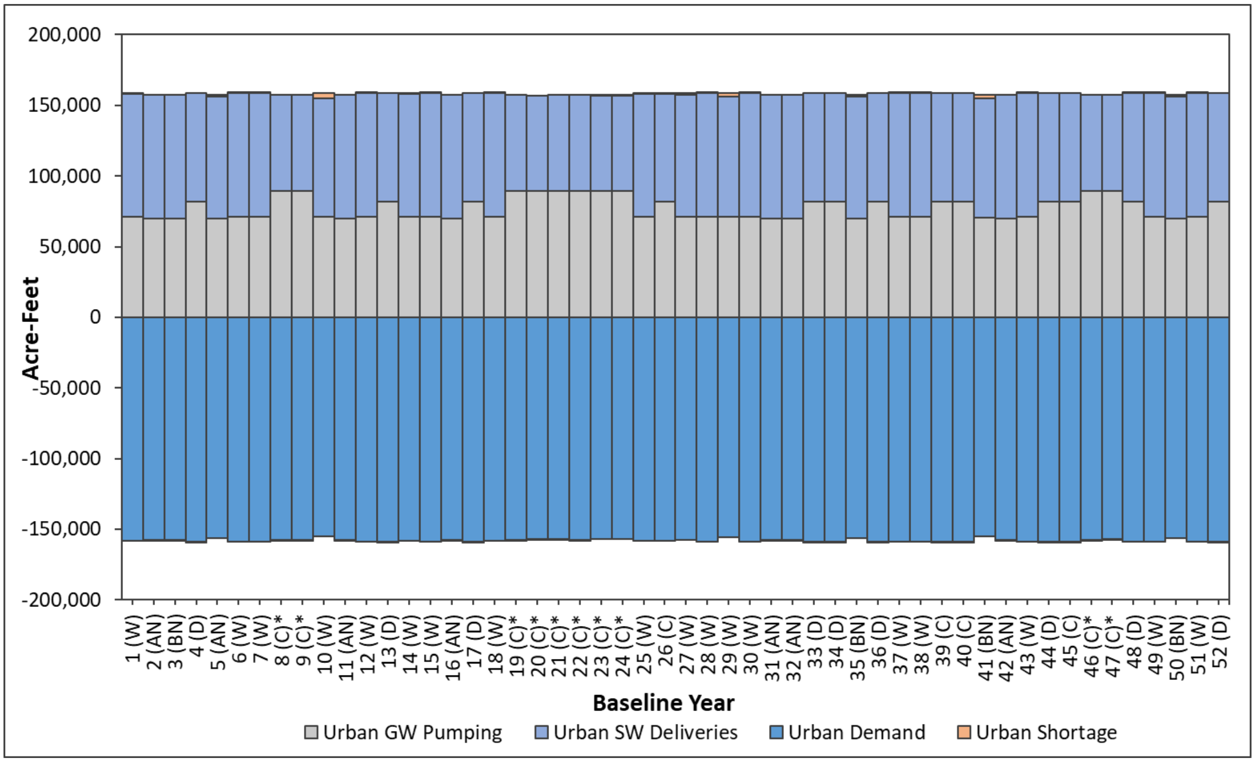


Figure 3: Eastern San Joaquin Subbasin Projected Urban Demand in the PCBL-PMA



3.1.2 Hydrologic Groundwater Budget

The primary components of the groundwater budget are the same as represented in the historical model. Corresponding to the major hydrologic processes affecting groundwater flow in the Subbasin, these are:

- Inflows:
    - Deep percolation (from rainfall and irrigation applied water)
    - Gain from stream (or recharge due to stream seepage)
    - Boundary inflow (from surrounding groundwater subbasins and the Sierra Nevada Mountains)
    - Other Recharge (from other sources such as irrigation canal seepage, managed aquifer recharge projects, and reservoir seepage)
- Outflows:
    - Groundwater pumping
    - Loss to stream (or outflow to streams and rivers)
    - Boundary outflow (to surrounding groundwater subbasins)
    - Change in groundwater storage (can be either an inflow or outflow)

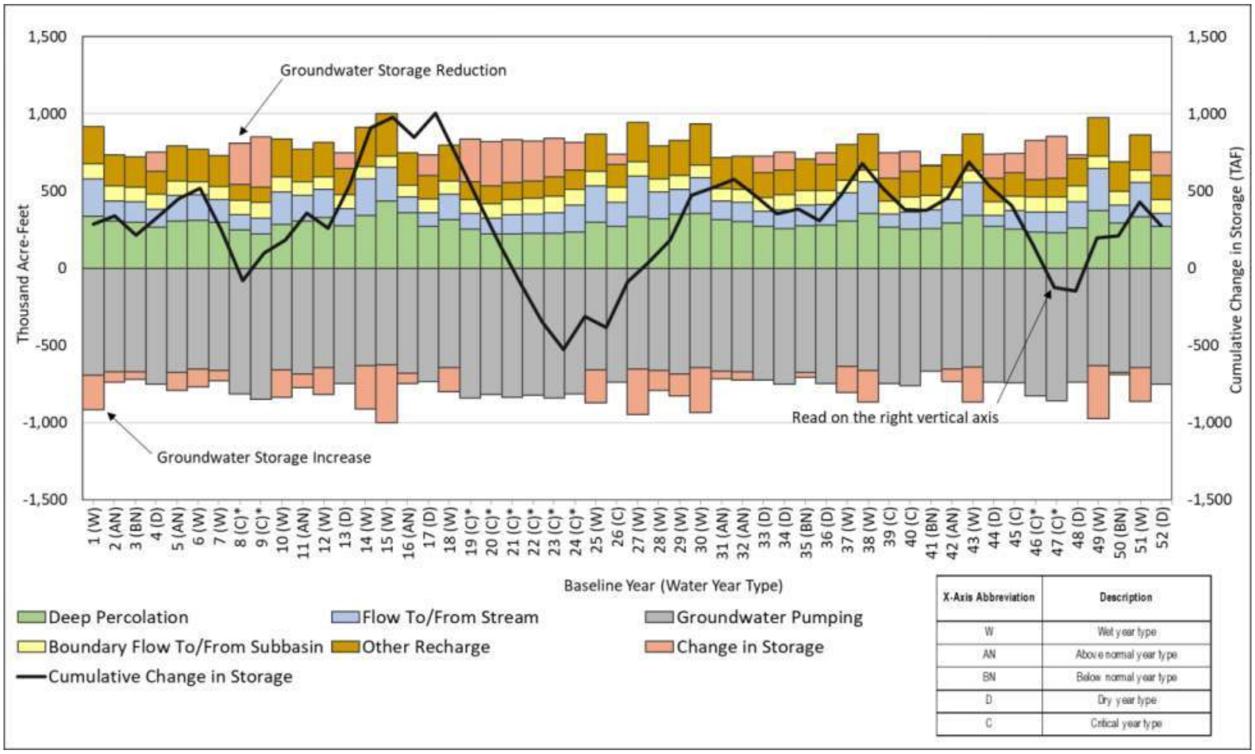
Pumping in the PCBL-PMA remains the largest component in the groundwater budget with an annual average 712,900 AFY. The PCBL-PMA offsets this pumping with 290,100 AFY of deep percolation, a net gain from stream of 151,800 AFY, 186,200 AFY of other recharge, and a total subsurface inflow of 90,100 AFY. The cumulative change in groundwater storage can be calculated from the annual change in groundwater storage. Due to inherent uncertainties in model input data, calculations, and calibration, all budget components have a degree of uncertainty. Given this uncertainty, the projected long-term average annual the groundwater storage deficit in ESJ Subbasin in the PCBL-PMA is -5,300 AFY, with the negative sign actually indicating an absence of groundwater overdraft and an increase in storage over the 52 years of the PCBL-PMA. These annual averages are shown in Table 3. The groundwater budgets, with average cumulative change in storage, are shown for the ESJ Subbasin in Figure 4.

Table 3 also includes the PCBL results and a Category A projects benefit calculated as the PCBL-PMA results minus the PCBL results. The results indicate that the Category A projects will resolve the PCBL Subbasin overdraft condition when impacts due to climate change are not included. Without projects, the modeling shows an average overdraft of 16,300 AFY over the 52 years of the PCBL simulation. With Category A projects in place, the modelling shows a projected overdraft of -5,300 AFY on average in the PCBL-PMA. The PCBL-PMA shows an average increase of 21,600 AFY of groundwater in storage when compared to the PCBL. Compared to the PCBL, with Category A projects modeled, the PCBL-PMA has 38,400 AFY less groundwater pumping due to the new in-lieu recharge projects, 24,500 AFY more recharge (both direct recharge projects and canal seepage losses for the in-lieu recharge projects), and 28,900 AFY less stream seepage into the groundwater system due to higher groundwater levels. Other hydrologic groundwater budget component differences are small between the PCBL and PCBL-PMA simulations.

Table 3: Eastern San Joaquin Subbasin Hydrologic Groundwater Budget Annual Average Comparison Between the PCBL (Version 2.0) and the PCBL-PMA

Hydrologic Groundwater Budget Component	Annual Average		
	PCBL (Version 2.0)	PCBL-PMA	PMA Benefit (PCBL-PMA minus PCBL)
Deep Percolation (AF)	282,100	290,100	8,000
Other Recharge (AF)	161,700	186,200	24,500
Net Stream Seepage (AF)	180,700	151,800	-28,900
Net Boundary Inflow (AF)	110,400	90,100	-20,300
Groundwater Pumping (AF)	751,300	712,900	-38,400
Change in Groundwater Storage (AF)	16,300	-5,300	-21,600

Figure 4: Eastern San Joaquin Subbasin Projected Hydrologic Groundwater Budget in the PCBL-PMA



3.2 Projected Conditions Baseline with Climate Change and Category A Projects and Management Actions

The section below summarizes the results for the PCBL-CC-PMA as compared to the PCBL-CC.

3.2.1 Land and Water Use Water Budget

The land and water use budget includes two different versions, agricultural and urban, and represents the balance of the model-calculated water demands with the water supplied. Both the agricultural and urban versions include the same components that make up the water balance:

- Inflows:
    - Groundwater pumping
    - Surface water deliveries
    - Shortage (if applicable)
- Outflows:
    - Demand (either agricultural or urban)
    - Surplus (if applicable)

The average annual PCBL-CC-PMA water demand for the Subbasin within the 52-year simulation period is 1,337,800 AFY, consisting of approximately 1,179,700 AFY of agricultural demand and 158,100 AFY of urban demand. This demand is met by an annual average of 570,700 AFY of surface water deliveries (490,200 AFY of agricultural and 80,500 AFY of urban deliveries) and is supplemented by 785,600 AFY of groundwater production (708,400 AFY of agricultural and 77,200 AFY of urban pumping). Due to uncertainties in the estimation of projected agricultural demand and historical supply records, there is about 19,000 AFY of surplus in the Subbasin scale agricultural water use budget, which is insignificant relative to the total volume of water use. Shortage and surplus represent a misalignment between the reported, estimated, or assumed water supply (groundwater pumping and surface water deliveries) and the calculated demands. In the projected conditions, there are uncertainties in the assumptions and parameters used for both monthly supply and demand estimates and/or calculations, resulting in misalignments, which is reported as shortage or surplus. These annual averages are shown in Table 4. The annual land and water use budgets across the ESJ Subbasin are shown in Figure 5 and Figure 6 for the Subbasin as a whole, showing the agricultural and urban, respectively, demands plotted with water supplies.

Table 4 also includes the PCBL-CC results and a Category A projects benefit calculated as the PCBL-CC-PMA results minus the PCBL-CC results. The PCBL-CC-PMA has an average of 37,800 AFY more surface water for agricultural purposes and 5,000 AFY more surface water for urban areas compared to the PCBL-CC. For urban areas, this represents an equivalent reduction in groundwater pumping of 5,000 AFY. For agricultural areas, the increased surface water results in 34,000 AFY less groundwater pumping, a number smaller than the amount of surface water provided due to a mismatch between the Category A water supplied and model-calculated agricultural demand on a monthly basis.

Differences between the amount of surface water supplied for PCBL-PMA and PCBL-CC-PMA are due to differences in the amount of surface water available in streams impacted by climate change. These differences are small (less than 200 AFY) between results in Table 2 and Table 4.

Table 4: Eastern San Joaquin Subbasin Land and Water Use Budget Annual Average Comparison Between the PCBL-CC and the PCBL-CC-PMA

Land and Water Use Budget Component	Annual Average		
	PCBL-CC	PCBL-CC-PMA	PMA Benefit (PCBL-CC-PMA minus PCBL-CC)
Agricultural Area (thousand acres)	359	359	0
Agricultural Demand (AF)	1,181,300	1,179,700	-1,600
Agricultural Groundwater Pumping (AF)	742,400	708,400	-34,000
Agricultural Surface Water Deliveries (AF)	452,400	490,200	37,800
Agricultural Shortage (AF)[1]	-13,500	-18,900	-5,500
Urban Area (thousand acres)	153	153	0
Urban Demand (AF)	158,100	158,100	0
Urban Groundwater Pumping (AF)	82,200	77,200	-5,000
Urban Surface Water Deliveries (AF)	75,500	80,500	5,000
Urban Shortage (AF)[1]	400	400	0

---

[1] Shortage and surplus represent a misalignment between the reported, estimated or assumed water supply (groundwater pumping and surface water deliveries) and the calculated demands. In the historical model, this can occur when there are inaccuracies in the reported water supplies or uncertainties in the methodology and/or parameters used to calculate the demand. In the projected conditions, there are uncertainties in the assumptions and parameters used for both monthly supply and demand estimates and/or calculations, resulting in misalignments, which is reported as shortage or surplus.

Figure 5: Eastern San Joaquin Subbasin Projected Agricultural Demand in the PCBL-CC-PMA

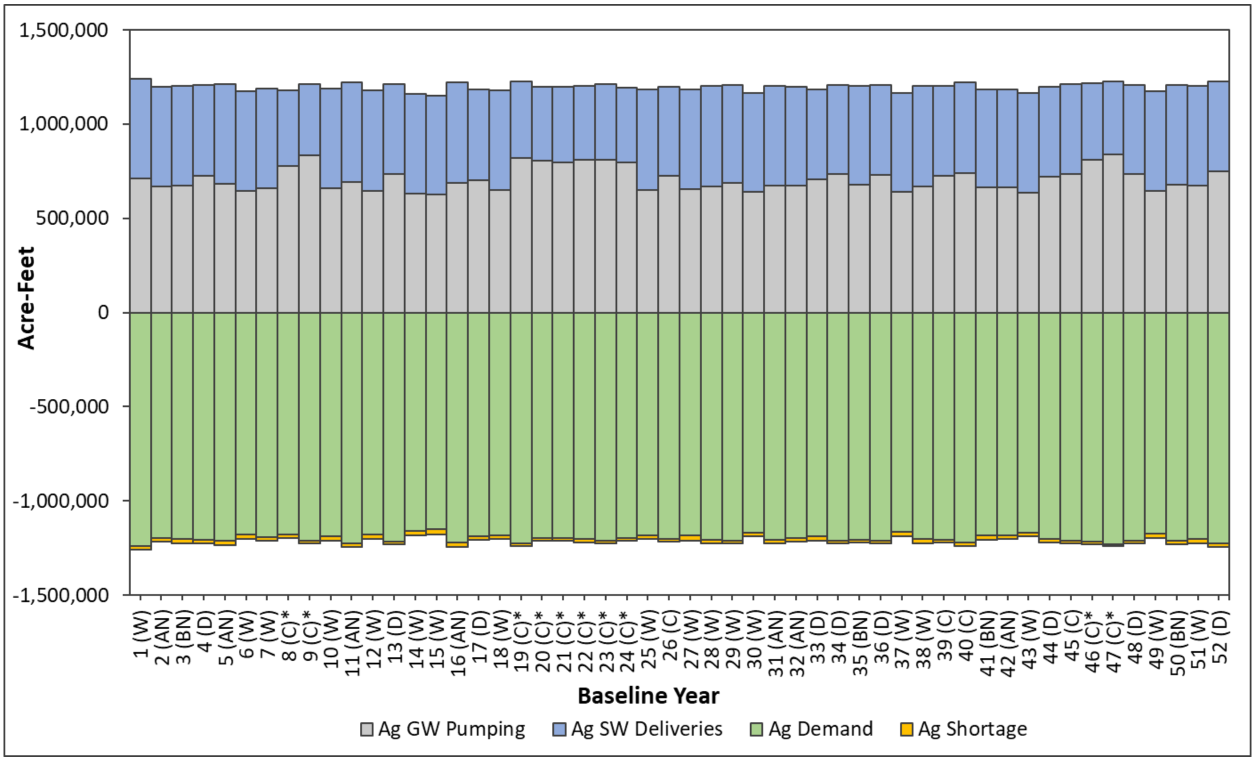
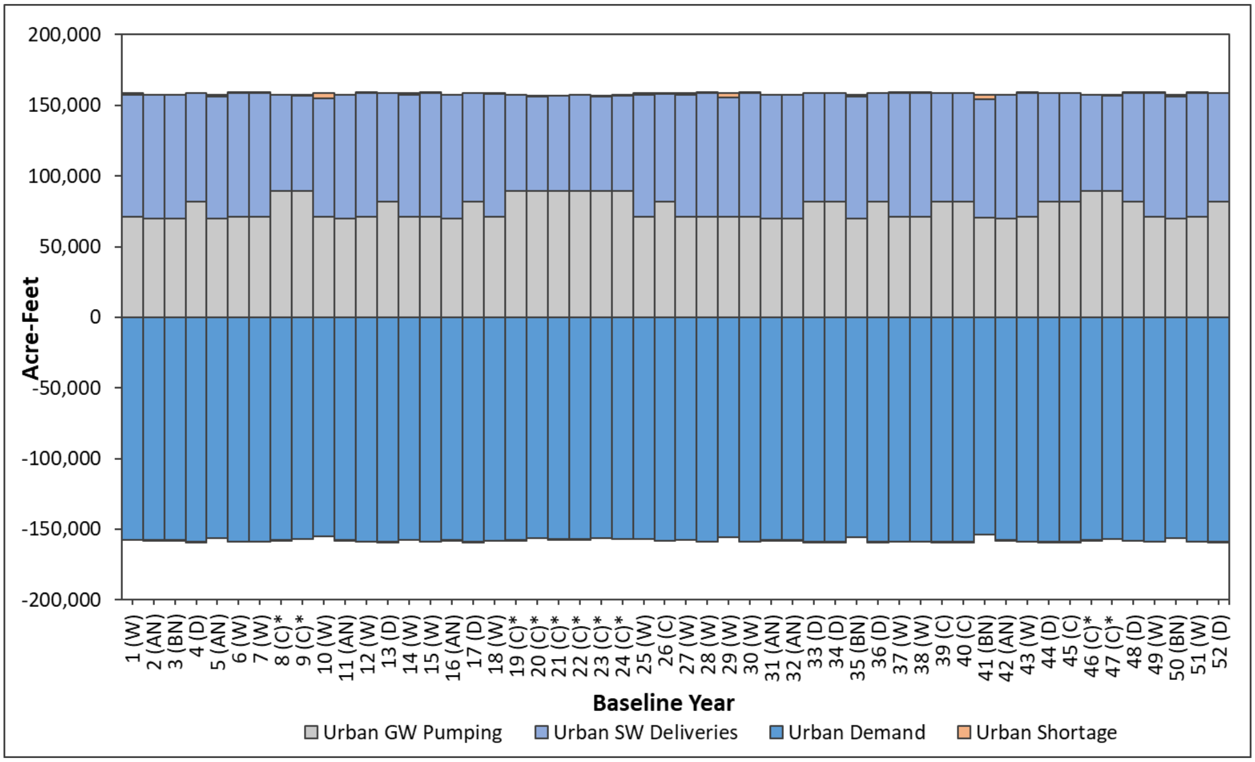


Figure 6: Eastern San Joaquin Subbasin Projected Urban Demand in the PCBL-CC-PMA



3.2.2 Hydrologic Groundwater Budget

The primary components of the groundwater budget are the same as represented in the historical model. Corresponding to the major hydrologic processes affecting groundwater flow in the Subbasin, these are:

- Inflows:
    - Deep percolation (from rainfall and irrigation applied water)
    - Gain from stream (or recharge due to stream seepage)
    - Boundary inflow (from surrounding groundwater subbasins and the Sierra Nevada Mountains)
    - Other Recharge (from other sources such as irrigation canal seepage, managed aquifer recharge projects, and reservoir seepage)
- Outflows:
    - Groundwater pumping
    - Loss to stream (or outflow to streams and rivers)
    - Boundary outflow (to surrounding groundwater subbasins)
    - Change in groundwater storage (can be either an inflow or outflow)

Pumping in the PCBL-CC-PMA remains the largest component in the groundwater budget with an annual average 794,100 AFY. The PCBL-CC-PMA offsets this pumping with 293,000 AFY of deep percolation, a net gain from stream of 189,800 AFY, 189,900 AFY of other recharge, and a total subsurface inflow of 105,700 AFY annually. The cumulative change in groundwater storage can be calculated from the annual change in groundwater storage. Due to inherent uncertainties in model input data, calculations, and calibration, all budget components have a degree of uncertainty. Given this uncertainty, the projected long-term average annual the groundwater storage deficit in ESJ Subbasin in the PCBL-CC-PMA is 15,700 AFY, indicating that groundwater overdraft is still occurring even with the Category A projects due to the impacts climate change on the Subbasin. These annual averages are shown in Table 5. The groundwater budgets, with average cumulative change in storage, are shown for the ESJ Subbasin in Figure 7.

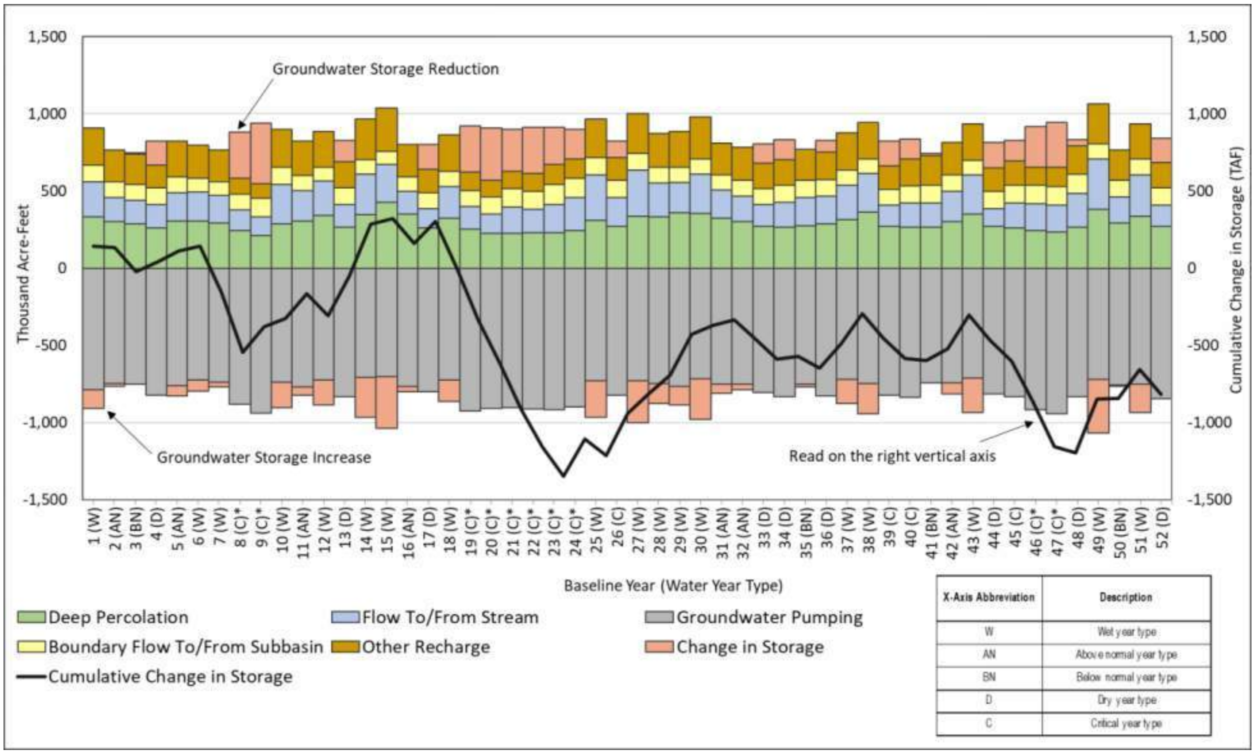
Table 5 also includes the PCBL results and a Category A projects benefit calculated as the PCBL-PMA results minus the PCBL results. While the groundwater storage deficit in the PCBL is projected to be corrected through the implementation of Category A projects as seen in PCBL-PMA, the modeling shows that when climate change is factored in for the PCBL-CC-PMA, there is still additional work (e.g., projects and/or management actions) that may need to be done to maintain subbasin sustainability. The PCBL-CC has a projected overdraft of 38,100 AFY. When projects are added in, as simulated in PCBL-CC-PMA, this overdraft amount is reduced to 15,700 AFY, but still represents continuing groundwater overdraft in the Subbasin that is not sustainable.

Compared to the PCBL-CC, with Category A projects modeled, the PCBL-CC-PMA has 39,000 AFY less groundwater pumping due to the new in-lieu recharge projects, 24,600 AFY more recharge (both direct recharge projects and canal seepage losses for the in-lieu recharge projects), and 28,300 AFY less stream seepage into the groundwater system due to higher groundwater levels. Other hydrologic groundwater budget component differences are small between the PCBL-CC and PCBL-CC-PMA simulations.

Table 5: Eastern San Joaquin Subbasin Hydrologic Groundwater Budget Annual Average Comparison Between the PCBL-CC and the PCBL-CC-PMA

Hydrologic Groundwater Budget Component	Annual Average		
	PCBL-CC	PCBL-CC-PMA	PMA Benefit (PCBL-CC-PMA minus PCBL-CC)
Deep Percolation (AF)	285,600	293,000	7,400
Other Recharge (AF)	165,300	189,900	24,600
Net Stream Seepage (AF)	218,100	189,800	-28,300
Net Boundary Inflow (AF)	126,000	105,700	-20,300
Groundwater Pumping (AF)	833,100	794,100	-39,000
Change in Groundwater Storage (AF)	38,100	15,700	-22,400

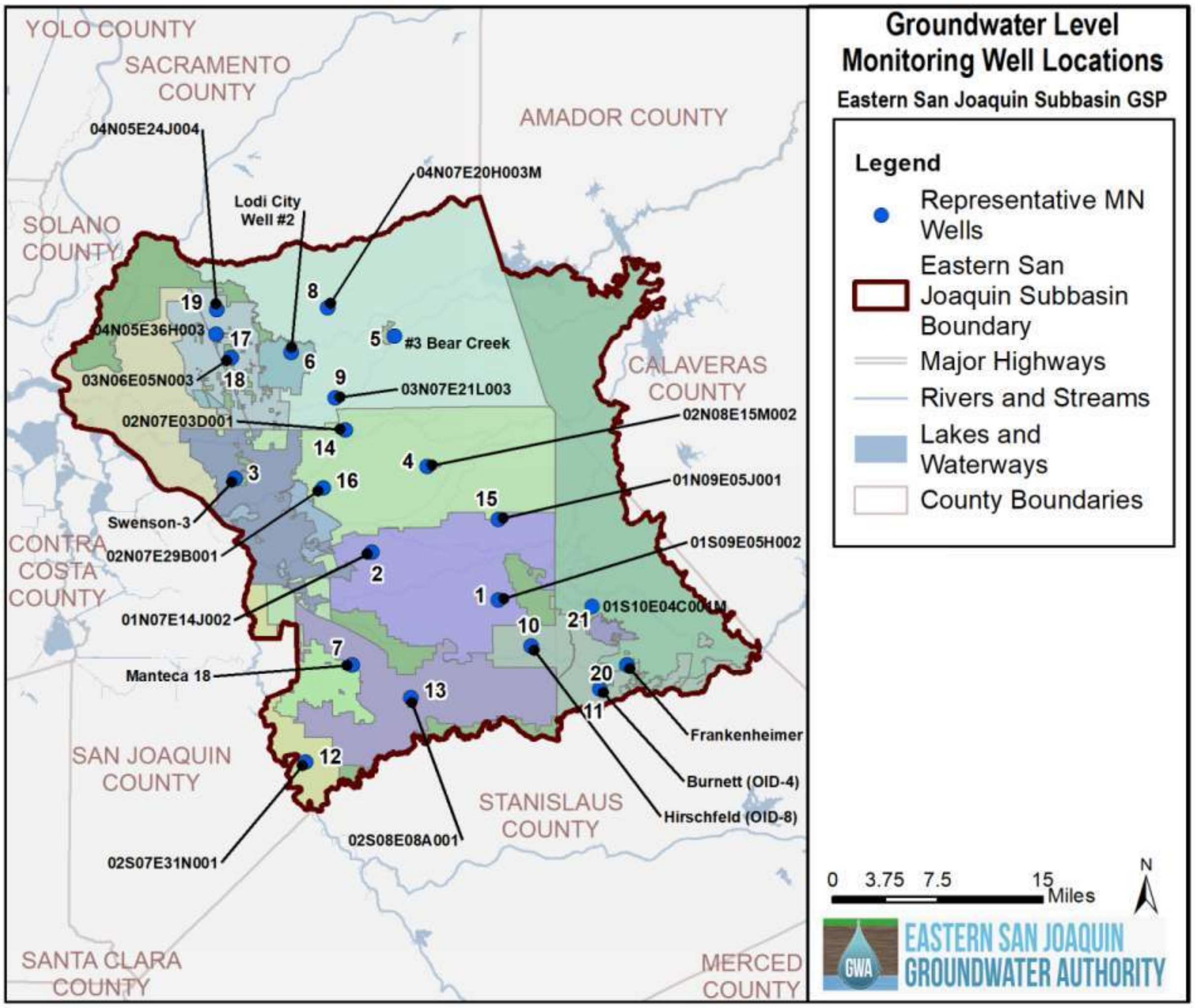
Figure 7: Eastern San Joaquin Subbasin Projected Hydrologic Groundwater Budget in the PCBL-CC-PMA



3.3 Groundwater Level Hydrographs

In order to evaluate how the chronic lowering of groundwater levels sustainability indicator might be impacted by Subbasin projected conditions, including climate change and Category A projects, groundwater hydrographs were analyzed for the 21 representative monitoring network wells selected in the GSP to monitor Subbasin groundwater levels. The goal of this analysis was to see where, when, and how often these groundwater hydrographs exceeded the minimum thresholds (MTs) established in the GSP. An undesirable result for groundwater levels as established in the GSP and refined in 2022 edits is when at least 25 percent of representative monitoring network wells (5 out of 21 wells) for the Subbasin are projected to exceed established minimum thresholds for two consecutive years. Figure 8 shows the location of these 21 representative monitoring network wells identified in the GSP as the monitoring network for the chronic lowering of groundwater levels.

Figure 8: Groundwater Level Representative Monitoring Well Locations



Groundwater level hydrographs at the 21 representative monitoring network wells were used to evaluate the impacts of the Category A Projects under the PCBL-PMA and PCBL-CC-PMA as compared to the PCBL and PCBL-CC, respectively. Five representative monitoring network wells (Well 01S09E05H002, Well Swenson-3, Well #3 Bear Creek, Well Hirschfeld (OID8), and Well 01S10E04C001) reported groundwater levels below their minimum thresholds for at least one month in any of the models evaluated (PCBL, PCBL-PMA, PCBL-CC, and PCBL-CC-PMA). The hydrographs of these five representative monitoring network wells are shown and discussed in Sections 3.3.1 and 3.3.2. The hydrographs for all of the 21 representative monitoring network wells are included in Appendix C. Subbasin undesirable results for groundwater levels are discussed in Section 3.3.3.

3.3.1 Projected Conditions Baseline without and with Category A Projects and Management Actions

Figure 9 shows the location of the two representative monitoring network wells (Well Swenson-3 and Well 01S10E04C001) with groundwater levels below their minimum thresholds at some any in the 52-year projection of the PCBL (without climate change or Category A projects). Figure 10 shows the location of the one representative monitoring network well (Well 01S10E04C001) with groundwater levels below its MT in the PCBL-PMA.

Figure 11 shows the hydrograph of Well Swenson-3 and

Figure 12 shows the hydrograph of Well 01S10E04C001. The hydrographs have horizontal lines representing the representative monitoring network well's minimum threshold (red) and measurable objective (green). The ESJWRM model results are shown for the PCBL (solid blue line), PCBL-PMA (dotted blue line), PCBL-CC (solid brown line), PCBL-CC-PMA (dotted brown line). Any point these lines cross the red minimum threshold line represents an exceedance in at least one month of the simulation. The hydrographs are discussed in further detail after the figures.

Figure 9: Groundwater Level Representative Monitoring Network Wells with MT Exceedances in the PCBL

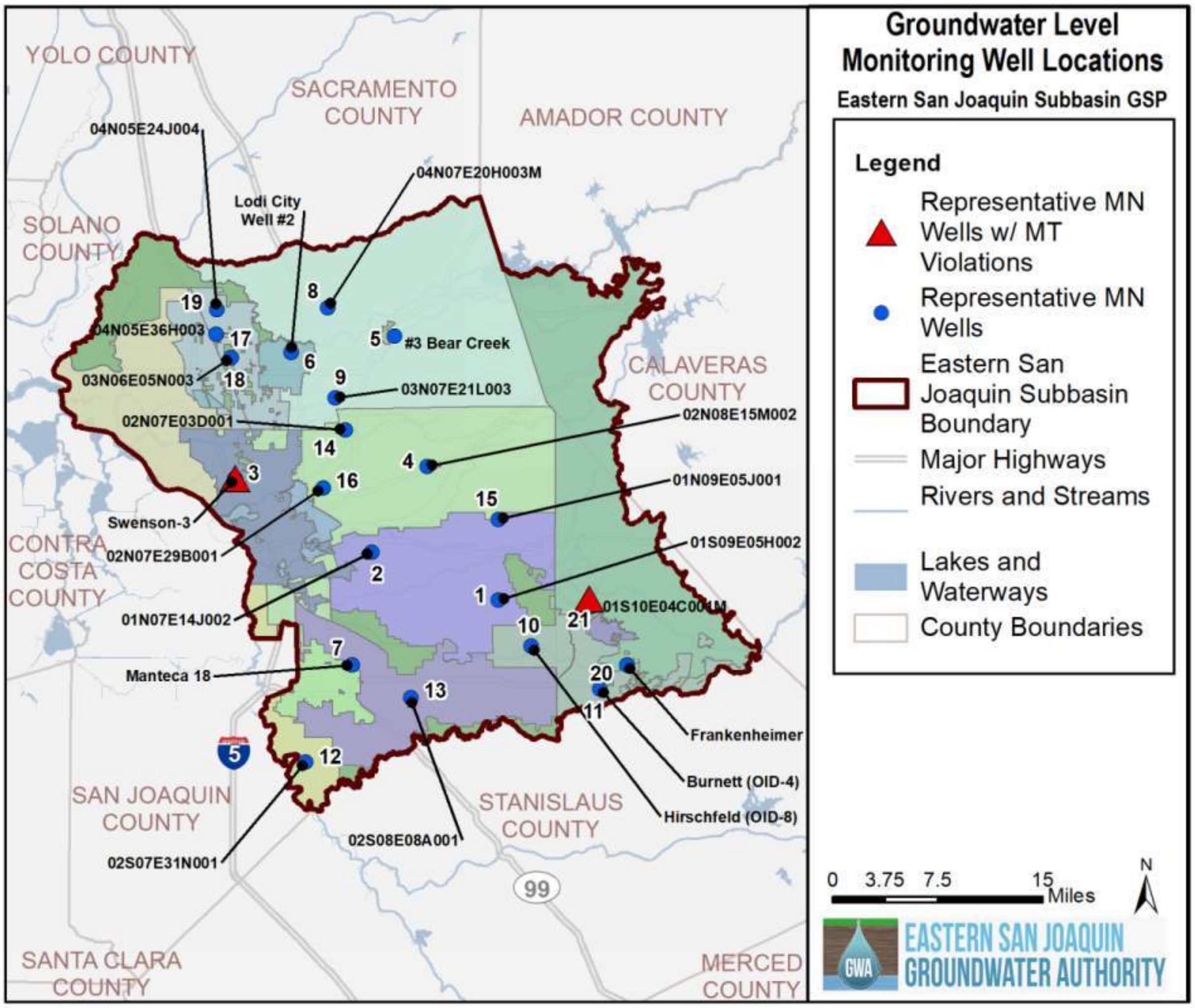


Figure 10: Groundwater Level Representative Monitoring Network Wells with MT Exceedances in the PCBL-PMA

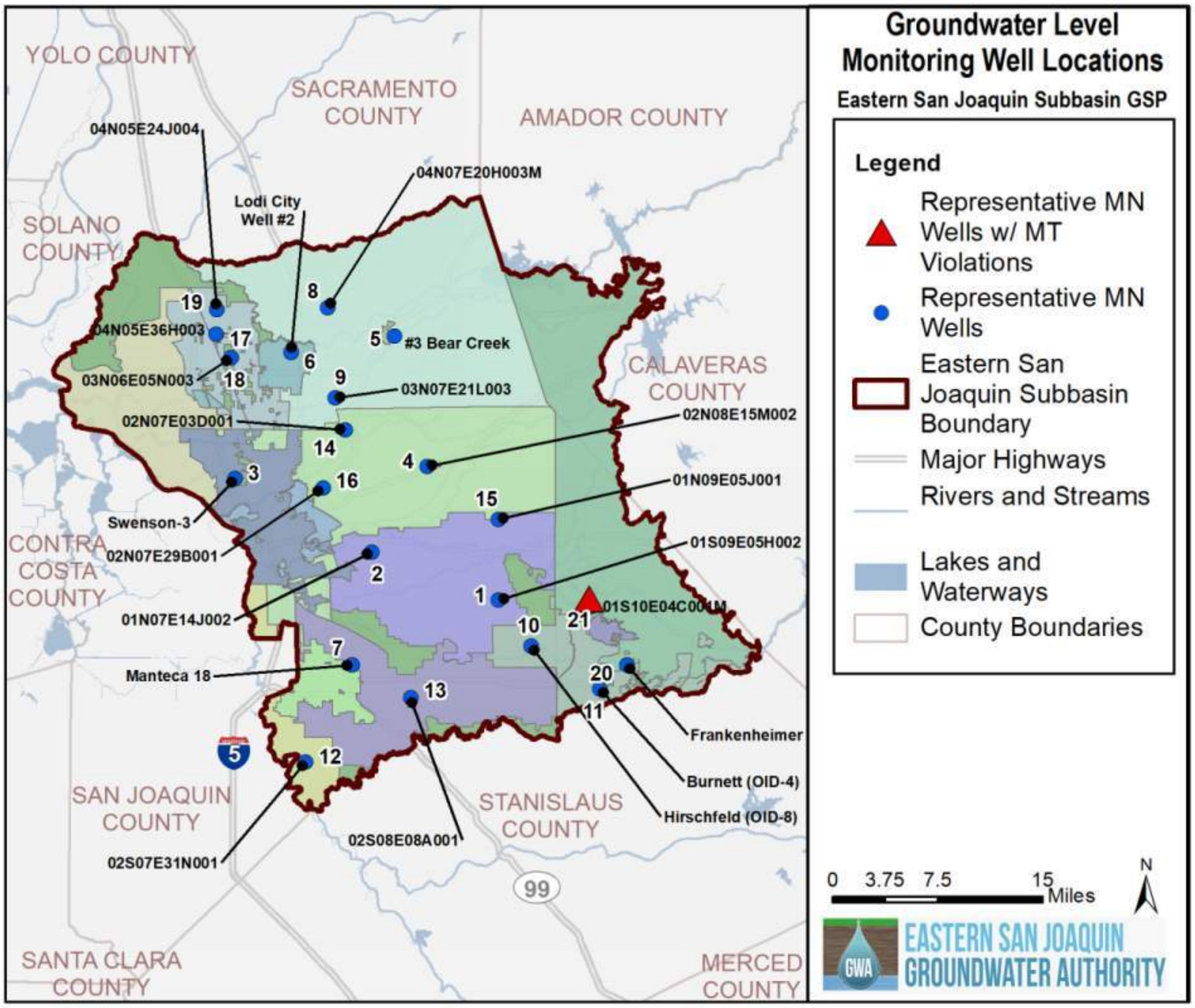


Figure 11: Groundwater Level Hydrograph for Well Swenson-3

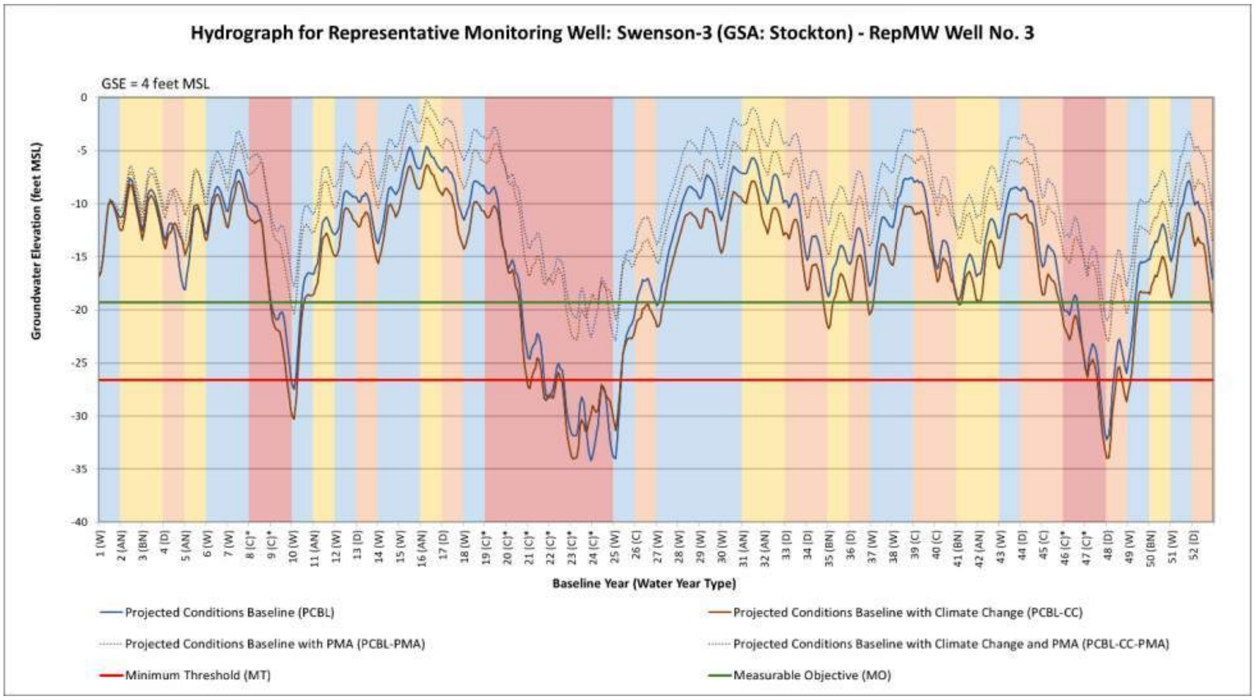
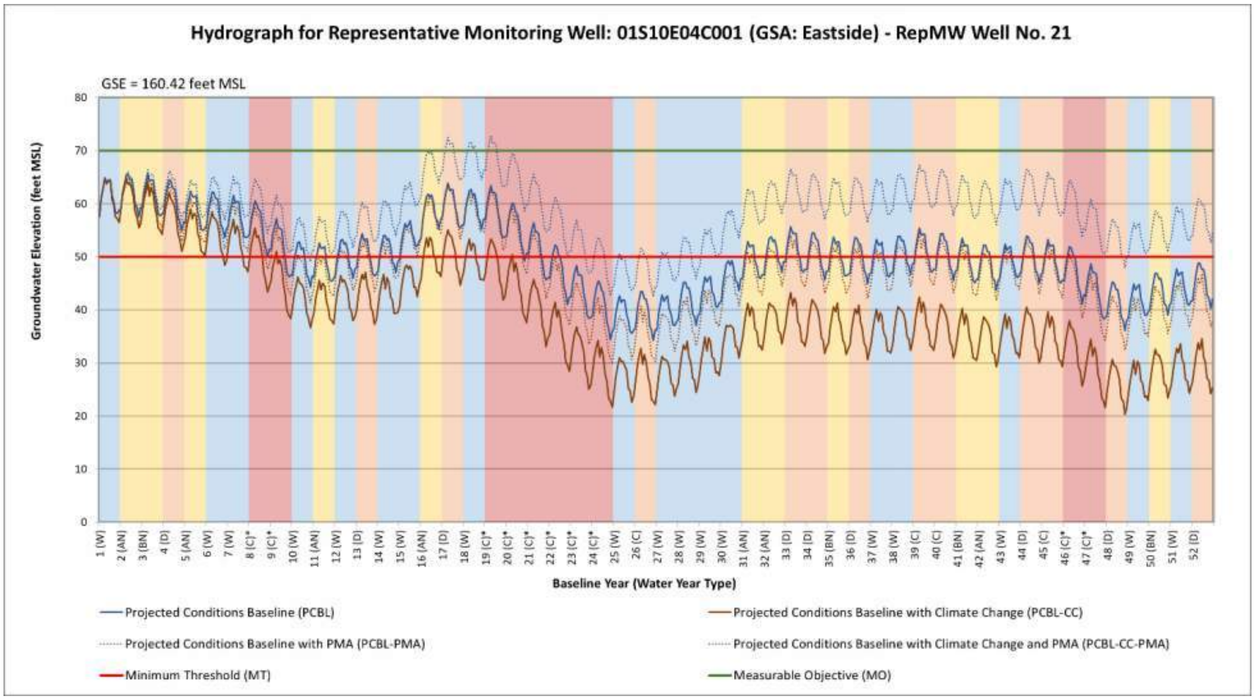


Figure 12: Groundwater Level Hydrograph for Well 01S10E04C001



Under the PCBL (without climate change or Category A projects), both representative monitoring network wells with hydrographs shown above in Figure 11 and

Figure 12 (Well Swenson-3 and Well 01S10E04C00) exceed their minimum thresholds The text below discusses when and how often MT exceedances occur for the two wells:

- Well Swenson-3:
    - Exceeds its MT in 48 months out of a total of 624 months (8% of all months) or 8 water years out of a total of 52 water years (15% of all water years).
    - The exceedances occur in October of Year 10 after 2 consecutive drought years, in July of Year 21 after 2 consecutive drought years with exceedances continuing for 5 consecutive water years in total, and in June of Year 47 after one drought year with exceedances continuing for 2 consecutive water years total.
- Well 01S10E04C00:
    - Exceeds its MT in 314 months out of a total of 624 months (50% of all months) and 41 water years out of a total of 52 water years (79% of all water years).
    - The exceedances occur in August of Year 8 in a drought year with exceedances continuing for 8 consecutive water years in total, and in August of Year 20 after a drought year with exceedances continuing for the remainder of the PCBL (33 consecutive water years in total).

Under the PCBL with Category A projects (PCBL-PMA), only one representative monitoring network well (Well 01S10E04C00 shown in

Figure 12) exceeds its MT.

- Well 01S10E04C00:
    - Exceeds its MT in 51 months out of a total of 624 months (8% of all months) and 10 water years out of a total of 52 water years (19% of all water years).
    - The exceedances occur in August of Year 10 after 2 consecutive drought years, in September of Year 22 after 3 consecutive drought years with exceedances continuing for 8 consecutive water years in total, and in July of Year 48 after 2 consecutive drought years.

As discussed in Section 3.1.2, when Category A projects are included in the ESJWRM, groundwater levels rise across the Subbasin due to the additional groundwater recharge projects and reduction in groundwater pumping from additional surface water diversions. Though groundwater levels rise overall, the impact to levels varies from area to area based on proximity to the Category A projects. In the PCBL water budget scenario with projects included (PCBL-PMA), projections show only one well falling below its minimum threshold for groundwater levels as compared to the two wells in the PCBL without Category A projects. In other words, the Category A projects caused one well that was exceeding its MT in the PCBL to no longer exceed its MT the PCBL-PMA. This well, located in the City of Stockton, has groundwater levels increasing due to the Category A projects occurring nearby.

3.3.2 Projected Conditions Baseline with Climate Change and without and with Category A Projects and Management Actions

Figure 13 shows the location of the five representative monitoring network wells (Well 01S09E05H002, Well Swenson-3, Well #3 Bear Creek, Well Hirschfeld (OID8), and Well 01S10E04C001) with projected groundwater levels falling below their MTs for groundwater levels at any point in the 52-year projection of the PCBL with climate change and without Category A projects (PCBL-CC). Figure 14 shows the location of the three representative monitoring network wells (Well 01S09E05H002, Hirschfeld (OID8), and Well 01S10E04C001) with groundwater levels falling below their MTs in the PCBL with climate change and with Category A projects (PCBL-CC-PMA).

Figure 15 shows the hydrograph of Well 01S09E05H002,

Figure 16 shows the hydrograph of Well #3 Bear Creek, and Figure 17 shows the hydrograph of Well Hirschfeld (OID8). The hydrographs for the other wells exceeding their MTs in the PCBL-CC and PCBL-CC-PMA were shown above in Figure 11 and

Figure 12. The hydrographs have horizontal lines representing the representative monitoring network well's minimum threshold (red) and measurable objective (green). The ESJWRM model results are shown for the PCBL (solid blue line), PCBL-PMA (dotted blue line), PCBL-CC (solid brown line), PCBL-CC-PMA (dotted brown line). Any point these lines cross the red minimum threshold line represents an exceedance in at least one month of the simulation. The hydrographs are discussed in further detail after the figures.

Figure 13: Groundwater Level Representative Monitoring Network Wells with MT Exceedances in the PCBL-CC

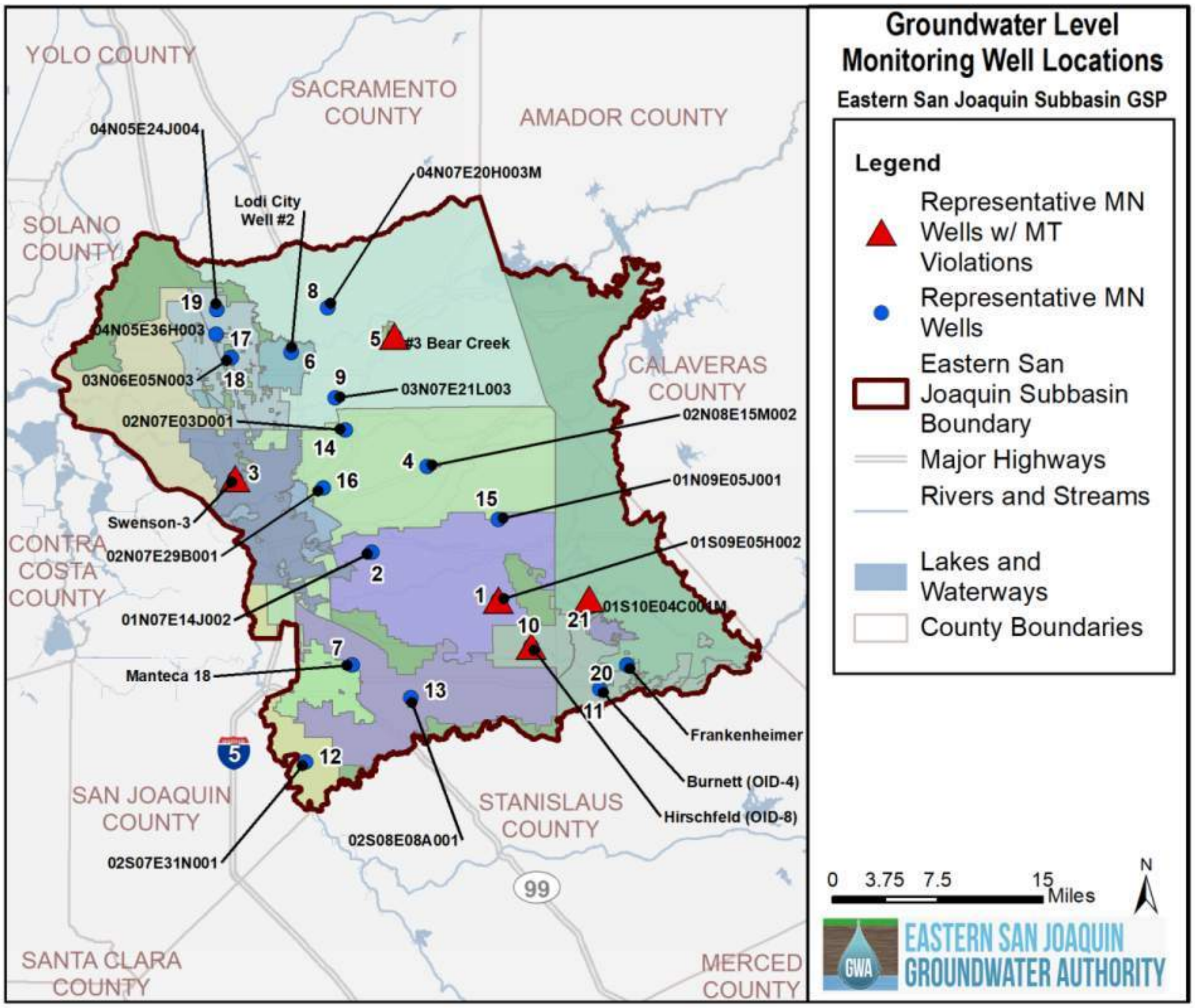


Figure 14: Groundwater Level Representative Monitoring Network Wells with MT Exceedances in the PCBL-CC-PMA

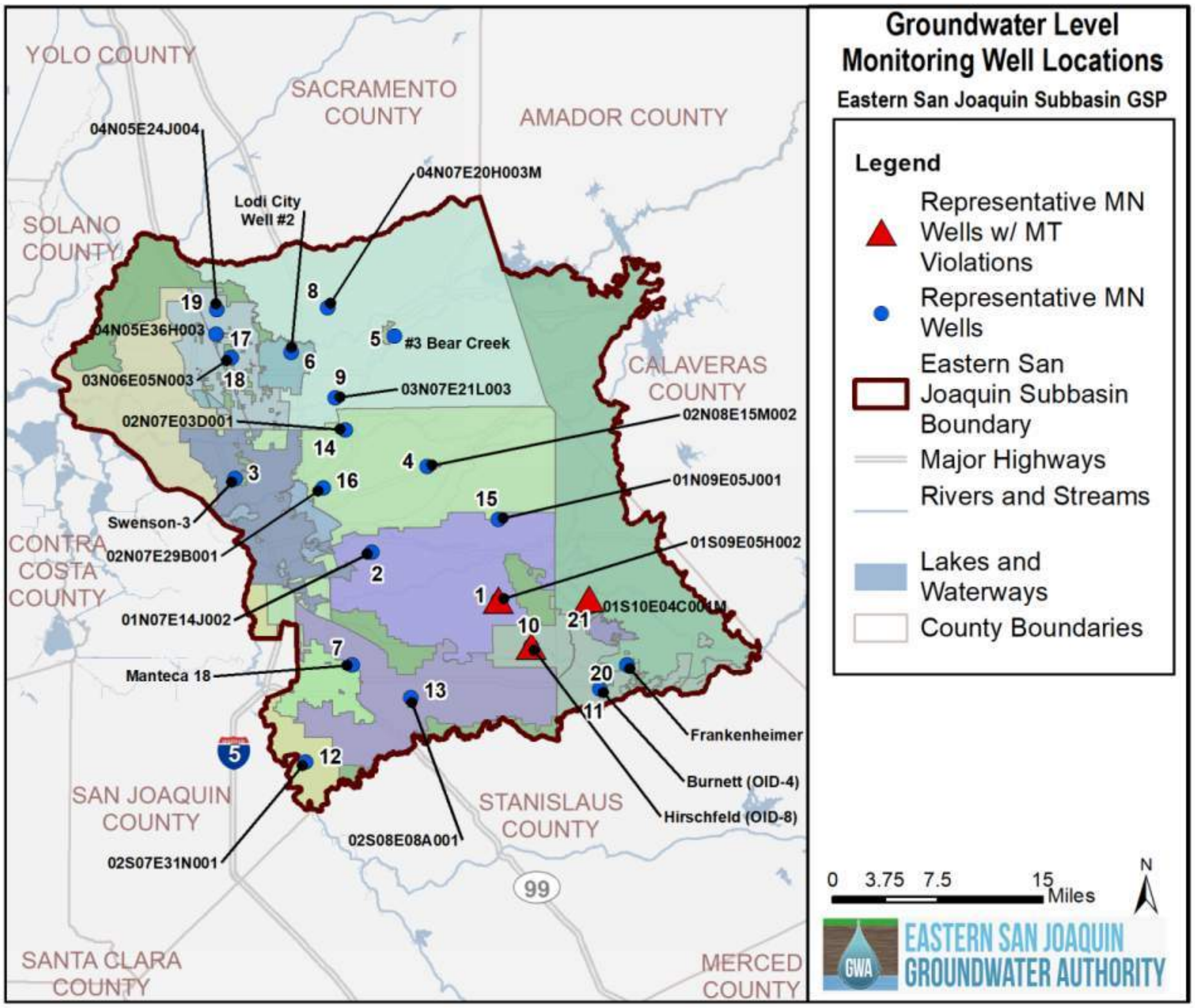


Figure 15: Groundwater Level Hydrograph for Well 01S09E05H002

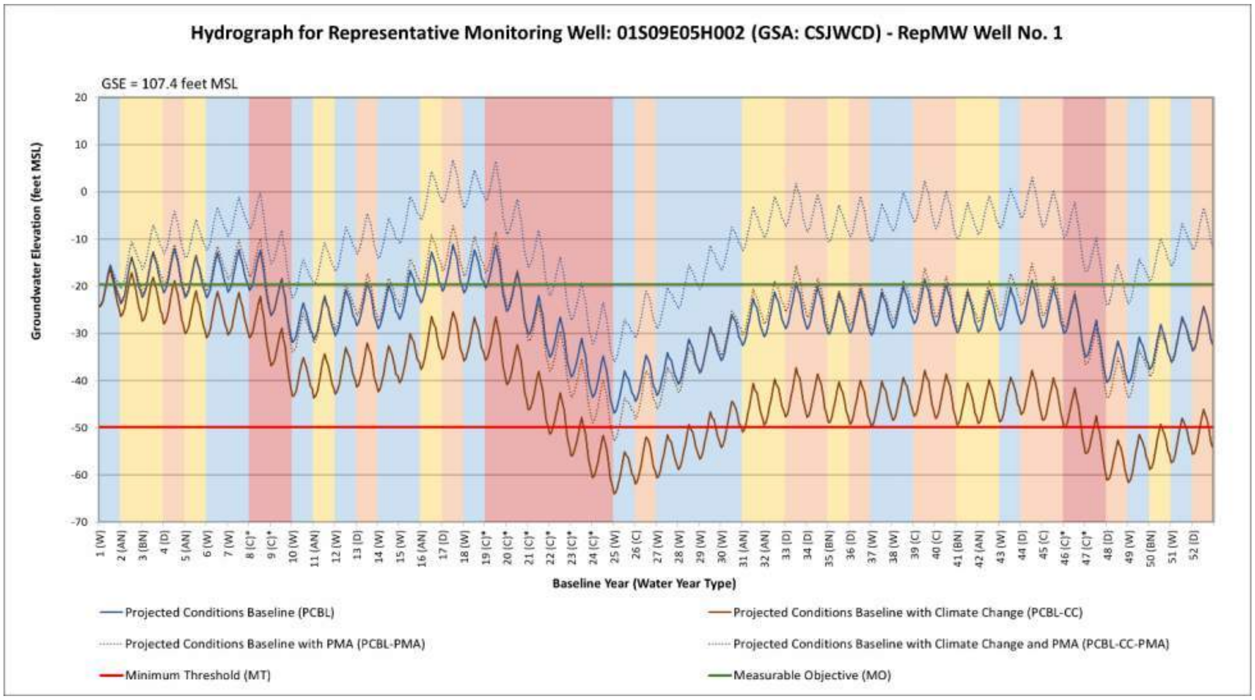


Figure 16: Groundwater Level Hydrograph for Well #3 Bear Creek

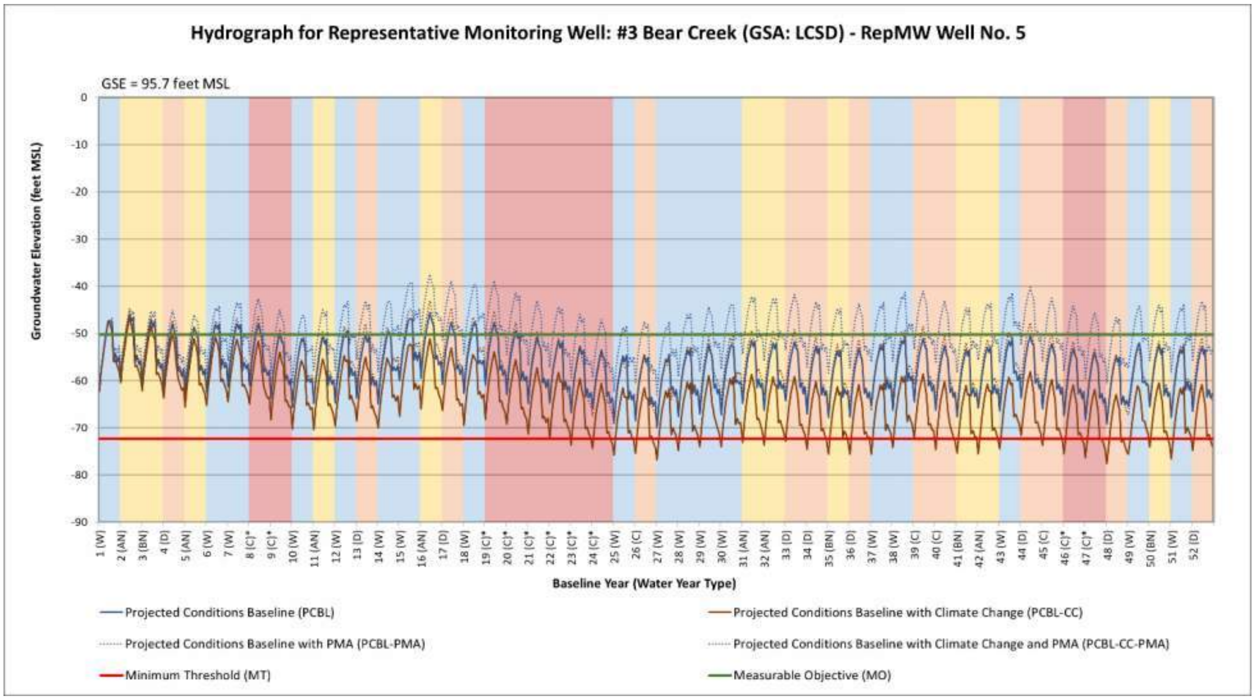
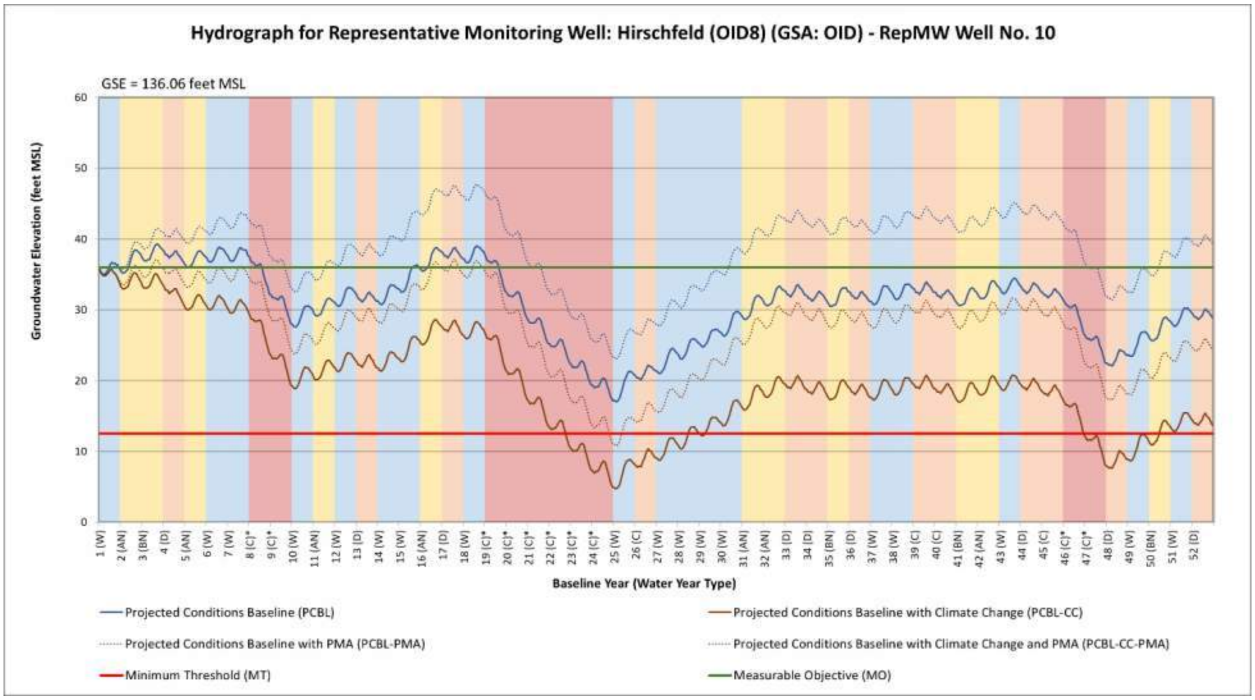


Figure 17: Groundwater Level Hydrograph for Well Hirschfeld (OID8)



Under the PCBL with climate change but without Category A projects (PCBL-CC), all five representative monitoring network wells (Well 01S09E05H002, Well Swenson-3, Well #3 Bear Creek, Well Hirschfeld (OID8), and Well 01S10E04C001) exceed their MTs.

- Well 01S09E05H002:
    - Exceeds its MT in 151 months out of a total of 624 months (24% of all months) and 17 water years out of a total of 52 water years (33% of all water years).
    - The exceedances occur in October of Year 22 after 3 consecutive drought years with exceedances continuing for 10 consecutive water years in total, and in October of Year 46 after 2 consecutive dry years with exceedances continuing for the remainder of the simulation or 7 consecutive water years in total.
- Well Swenson-3:
    - Exceeds its MT in 65 months out of a total of 624 months (10% of all months) and 10 water years out of a total of 52 water years (19% of all water years).
    - The exceedances occur in July of Year 9 after 1 drought year with exceedances continuing for 2 consecutive water years in total, in October of Year 21 after 2 consecutive drought years with exceedances continuing for 5 consecutive water years in total, and in May of Year 47 after 1 drought year with exceedances continuing for 3 consecutive water years in total.
- Well #3 Bear Creek:
    - Exceeds its MT in 52 months out of a total of 624 months (8% of all months) and 29 water years out of a total of 52 water years (56% of all water years).
    - The exceedances occur in October of Year 22 after 3 consecutive drought years with exceedances continuing for 17 consecutive water years in total, in October of Year 40 after a dry year with exceedances continuing for 4 consecutive water years in total, and in October of

Year 45 after a dry year with exceedances continuing for the remainder of the simulation or 8 consecutive water years in total.

- Well Hirschfeld (OID8):
  - Exceeds its MT in 113 months out of a total of 624 months (18% of all months) and 13 water years out of a total of 52 water years (25% of all water years).
  - The exceedances occur in August of Year 22 after 3 consecutive drought years with exceedances continuing for 8 consecutive water years in total, and in September of Year 46 after 2 consecutive dry years with exceedances continuing for 5 consecutive water years in total.
- Well 01S10E04C001:
  - Exceeds its MT in 512 months out of a total of 624 months (82% of all months) and 47 water years out of a total of 52 water years (90% of all water years).
  - The exceedances occur in July of Year 6 after a normal year with exceedances continuing for the remainder of the simulation or 47 consecutive water years in total.

Under the PCBL with climate change and with Category A projects (PCBL-CC-PMA), three representative monitoring network wells (Well 01S09E05H002, Well Hirschfeld (OID8), and Well 01S10E04C001) exceed their MTs.

- Well 01S09E05H002:
  - Exceeds its MT in 4 months out of a total of 624 months (1% of all months) and 2 water years out of a total of 52 water years (4% of all water years).
  - The exceedances occur in September of Year 24 after 5 consecutive drought years with exceedances continuing for 2 consecutive water years in total.
- Well Hirschfeld (OID8):
  - Exceeds its MT in 7 months out of a total of 624 months (1% of all months) and 2 water years out of a total of 52 water years (4% of all water years).
  - The exceedances occur in September of Year 24 after 5 consecutive drought years with exceedances continuing for 2 consecutive water years in total.
- Well 01S10E04C001:
  - Exceeds its MT in 375 months out of a total of 624 months (60% of all months) and 41 water years out of a total of 52 water years (79% of all water years).
  - The exceedances occur in July of Year 8 in a drought year with exceedances continuing for 8 consecutive water years in total, and in July of Year 20 after a drought year with exceedances continuing for the remainder of the simulation or 33 consecutive water years in total.

Similar to what was seen with the PCBL and PCBL-PMA and as discussed in Section 3.2.2, Category A projects raise groundwater levels in varying amounts across the Subbasin. As seen with the five wells with MT exceedances in the PCBL-CC, the effects of climate change may continue to significantly impact Subbasin groundwater overdraft and groundwater levels in the future. In the PCBL water budget scenario with projects and climate change factored in (PCBL-CC-PMA), modeling results show three wells still falling below their MTs for groundwater levels in the 52-year projection. All three of these wells are clustered in the same area of the Subbasin, perhaps indicating the need for additional study or a targeted project or management action specific to this area. The two wells that exceeded their MTs under PCBL-CC, but no longer exceeded under PCBL-CC-PMA were located in the areas with Category A projects.

3.3.3 Groundwater Levels Undesirable Result

An undesirable result for groundwater levels is considered to occur during GSP implementation when at least 25 percent of representative monitoring network wells (5 of 21 wells in the Subbasin) fall below their MTs for two consecutive years. Figure 18 shows the number of wells with 2 consecutive water years of exceedances in the PCBL, PCBL-CC, PCBL-PMA and PCBL-CC-PMA models over 51 years of the simulation (since Year 1 cannot have 2 consecutive years of exceedances). Table 6 shows the number of water years out of the total possible 51 years with 2 consecutive years of exceedances in the same four simulations. All of the simulations have consecutive water years with MT exceedances occurring in at least one well. Only the PCBL-CC model is considered to have an undesirable result with five simulation years (Year 23, 24, 25, 48, and 49) with five representative monitoring network wells exceeding their MTs. These five years are all during or immediately following extreme drought conditions. No undesirable results were triggered in the PCBL, PCBL-PMA, and PCBL-CC-PMA models.

Figure 18: Number of Wells with 2 Consecutive Water Years of Exceedances

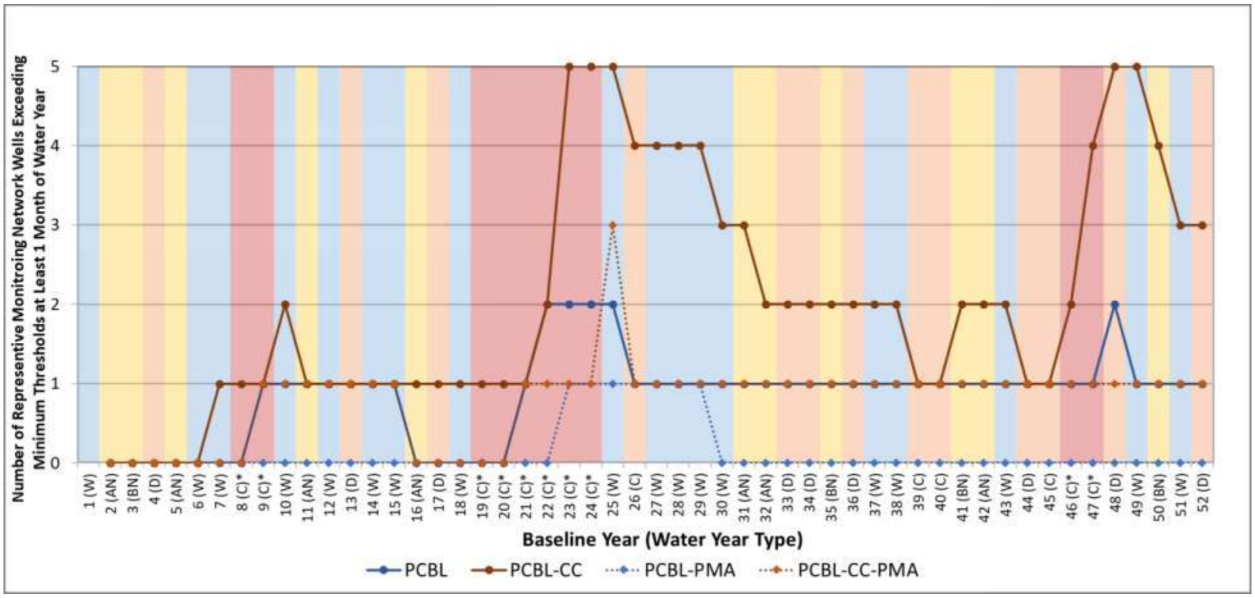


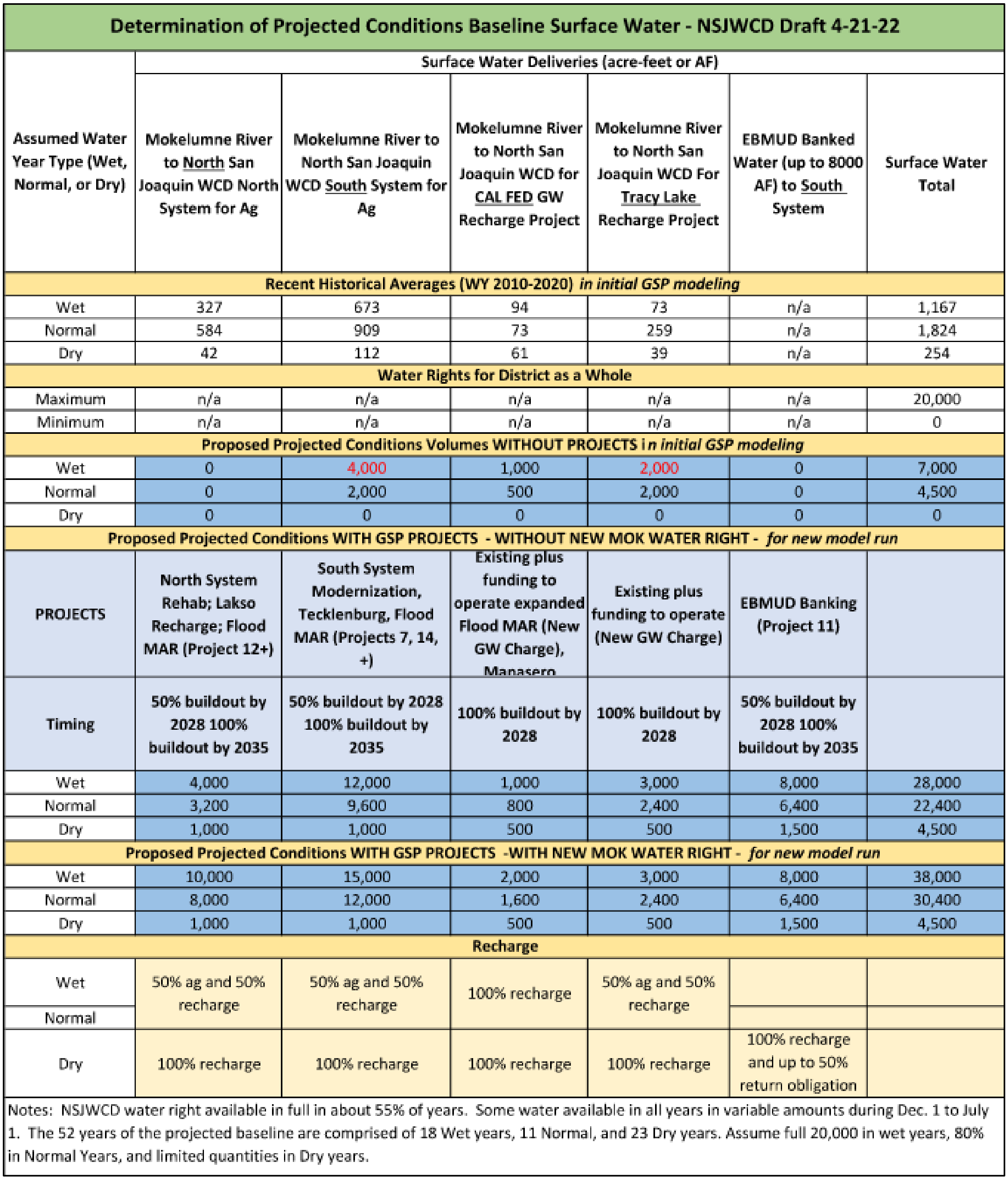
Table 6: Number of Water Years Out of Total with 2 Consecutive Years of Exceedances

Number of Water Years where Wells Have 2 Consecutive Years of Exceedances	PCBL (Version 2.0)	PCBL-PMA	PCBL-CC	PCBL-CC-PMA
1 Well	34	7	18	38
2 Wells	5	0	13	0
3 Wells	0	0	4	1
4 Wells	0	0	6	0
5 Wells	0	0	5	0

4. References

Woodard & Curran. 2022. Eastern San Joaquin Water Resources Model (ESJWRM) Version 2.0 Update. Prepared for Eastern San Joaquin Groundwater Authority.

APPENDIX A: NSJWCD PROJECT NUMBERS PROVIDED BY JENNIFER SPALETTA ON APRIL 21, 2022



Determination of Projected Conditions Baseline Surface Water - NSJWCD Draft 4-21-22

	Surface Water Deliveries (acre-feet or AF)					
Assumed Water Year Type (Wet, Normal, or Dry)	**Mokelumne River to North San Joaquin WCD North System for Ag**	**Mokelumne River to North San Joaquin WCD South System for Ag**	**Mokelumne River to North San Joaquin WCD for CAL FED GW Recharge Project**	**Mokelumne River to North San Joaquin WCD For Tracy Lake Recharge Project**	**EBMUD Banked Water (up to 8000 AF) to South System**	**Surface Water Total**
Recent Historical Averages (WY 2010-2020) ***in initial GSP modeling***						
Wet	327	673	94	73	n/a	1,167
Normal	584	909	73	259	n/a	1,824
Dry	42	112	61	39	n/a	254
Water Rights for District as a Whole						
Maximum	n/a	n/a	n/a	n/a	n/a	20,000
Minimum	n/a	n/a	n/a	n/a	n/a	0
Proposed Projected Conditions Volumes WITHOUT PROJECTS i*n initial GSP modeling*						
Wet	0	4,000	1,000	2,000	0	7,000
Normal	0	2,000	500	2,000	0	4,500
Dry	0	0	0	0	0	0
Proposed Projected Conditions WITH GSP PROJECTS - WITHOUT NEW MOK WATER RIGHT - ***for new model run***						
PROJECTS	**North System Rehab; Lakso Recharge; Flood MAR (Project 12+)**	**South System Modernization, Tecklenburg, Flood MAR (Projects 7, 14, +)**	**Existing plus funding to operate expanded Flood MAR (New GW Charge), Manasero**	**Existing plus funding to operate (New GW Charge)**	**EBMUD Banking (Project 11)**	
Timing	**50% buildout by 2028 100% buildout by 2035**	**50% buildout by 2028 100% buildout by 2035**	**100% buildout by 2028**	**100% buildout by 2028**	**50% buildout by 2028 100% buildout by 2035**	
Wet	4,000	12,000	1,000	3,000	8,000	28,000
Normal	3,200	9,600	800	2,400	6,400	22,400
Dry	1,000	1,000	500	500	1,500	4,500
Proposed Projected Conditions WITH GSP PROJECTS -WITH NEW MOK WATER RIGHT - ***for new model run***						
Wet	10,000	15,000	2,000	3,000	8,000	38,000
Normal	8,000	12,000	1,600	2,400	6,400	30,400
Dry	1,000	1,000	500	500	1,500	4,500
Recharge						
Wet	50% ag and 50% recharge	50% ag and 50% recharge	100% recharge	50% ag and 50% recharge		
Normal						
Dry	100% recharge	100% recharge	100% recharge	100% recharge	100% recharge and up to 50% return obligation	

Notes: NSJWCD water right available in full in about 55% of years. Some water available in all years in variable amounts during Dec. 1 to July 1. The 52 years of the projected baseline are comprised of 18 Wet years, 11 Normal, and 23 Dry years. Assume full 20,000 in wet years, 80% in Normal Years, and limited quantities in Dry years.

APPENDIX B: ADDITIONAL PROJECTS PROPOSED AS CATEGORY A

The following projects were initially proposed as Category A projects, but were removed due to a lack of additional information provided. The information below is the project understanding as was understood at the time.

City of Stockton Morada Detention Basin

Submitting GSA: City of Stockton and Woodbridge Irrigation District (WID)

Project Source: Project not included in GSP. Added based on information provided by personal communication with Mel Lytle (City of Stockton), Eric Houston (City of Stockton), and Mitchell Maidrand (City of Stockton) on April 21, 2022.

Project Type: Direct Recharge

Water Source: This project relies on water from the Mokelumne River. This is an existing water right held by WID under both pre-1914 and post-1914 appropriative rights. Stormwater may also be utilized for recharge purposes.

Delivery Area: Morada Detention Basin (approximately 14.2 acres)

Project Overview: This project is part of an agreement between City of Stockton and Woodbridge Irrigation District in September 2017 to use three storm basins in the northern part of City of Stockton for groundwater recharge of WID water. WID plans to use its pre-1914 unappropriated flows from the Mokelumne River and routed through WID's South Canal and the Davis-Dolan Lateral. These flows could be supplemented with recovered stormwater during the winter months. One basin, the Morada Detention Basin, previously had groundwater recharge operations occur over the seven years from 2003 through 2009 with previous studies conducted by USGS indicating a positive response in groundwater levels due to recharge operations. WID plans to utilize two additional basins (Cannery Park Northwest and Northeast Basins) where Mokelumne River flows or flood release water will be applied for groundwater recharge. The original contract between City of Stockton and WID for the use of the storm basins expires on June 30, 2027 and will need to be extended.

Project Volume:

No information on the availability of WID's excess Mokelumne River water has been provided. Until more information becomes available, no water is assumed to be recharged in this project.

Baseline Water Year Type	Annual Volume (acre-feet per year or AFY)	Notes
Drought	0	
Dry	0	
Normal	0	
Wet	0	

Woodbridge Irrigation District Cannery Park Regulating Basins

Submitting GSA: City of Stockton and Woodbridge Irrigation District (WID)

Project Source: Project not included in GSP. Added based on information provided by personal communication with Mel Lytle (City of Stockton), Eric Houston (City of Stockton), and Mitchell Maidrand (City of Stockton) on April 21, 2022.

Project Type: Direct Recharge

Water Source: This project relies on water from the Mokelumne River. This is an existing water right held by WID under both pre-1914 and post-1914 appropriative rights. Stormwater may also be utilized for recharge purposes.

Delivery Area: Cannery Park Northeast and Northwest Basins (approximately 15 acres)

Project Overview: This project is part of an agreement between City of Stockton and Woodbridge Irrigation District in September 2017 to use three storm basins in the northern part of City of Stockton for groundwater recharge of WID water. WID plans to use its pre-1914 unappropriated flows off the Mokelumne River and routed through WID's South Canal and the Davis-Dolan Lateral. These flows could be supplemented with recovered stormwater during the winter months. One basin, the Morada Detention Basin, previously had groundwater recharge operations occur over the seven years from 2003 through 2009 with previous studies conducted by USGS indicating a positive response in groundwater levels due to recharge operations. WID plans to utilize two additional basins (Cannery Park Northwest and Northeast Basins) where Mokelumne River flows or flood release water will be applied for groundwater recharge. The original contract between City of Stockton and WID for the use of the storm basins expires on June 30, 2027 and will need to be extended.

Project Volume:

No information on the availability of WID's excess Mokelumne River water has been provided. Until more information becomes available, no water is assumed to be recharged in this project.

Baseline Water Year Type	Annual Volume (acre-feet per year or AFY)	Notes
Drought	0	
Dry	0	
Normal	0	
Wet	0	

APPENDIX C: GROUNDWATER LEVEL HYDROGRAPHS

Figure C-1: Groundwater Level Representative Monitoring Well Locations

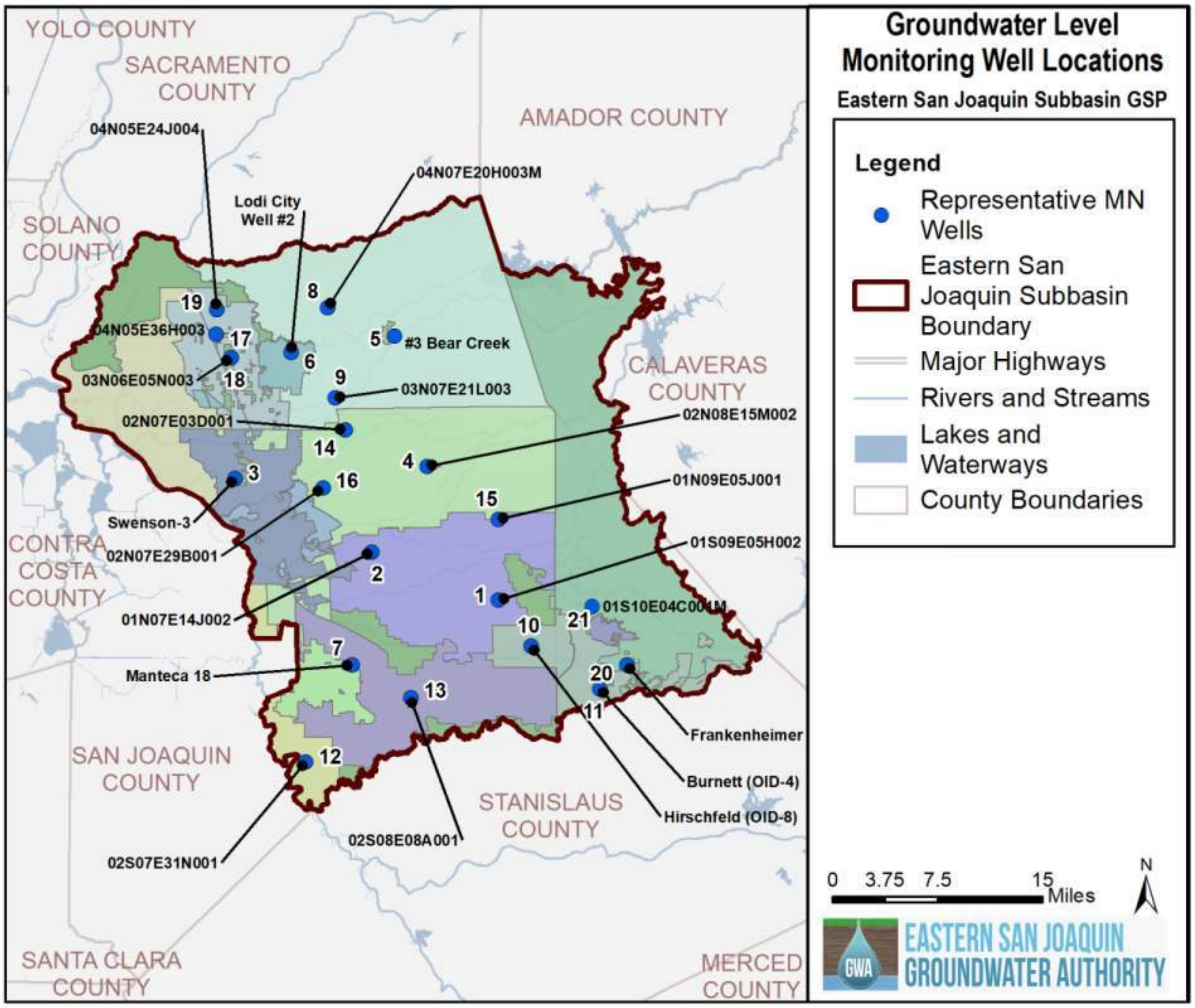


Figure C-2: Groundwater Level Hydrograph for Well 01S09E05H002

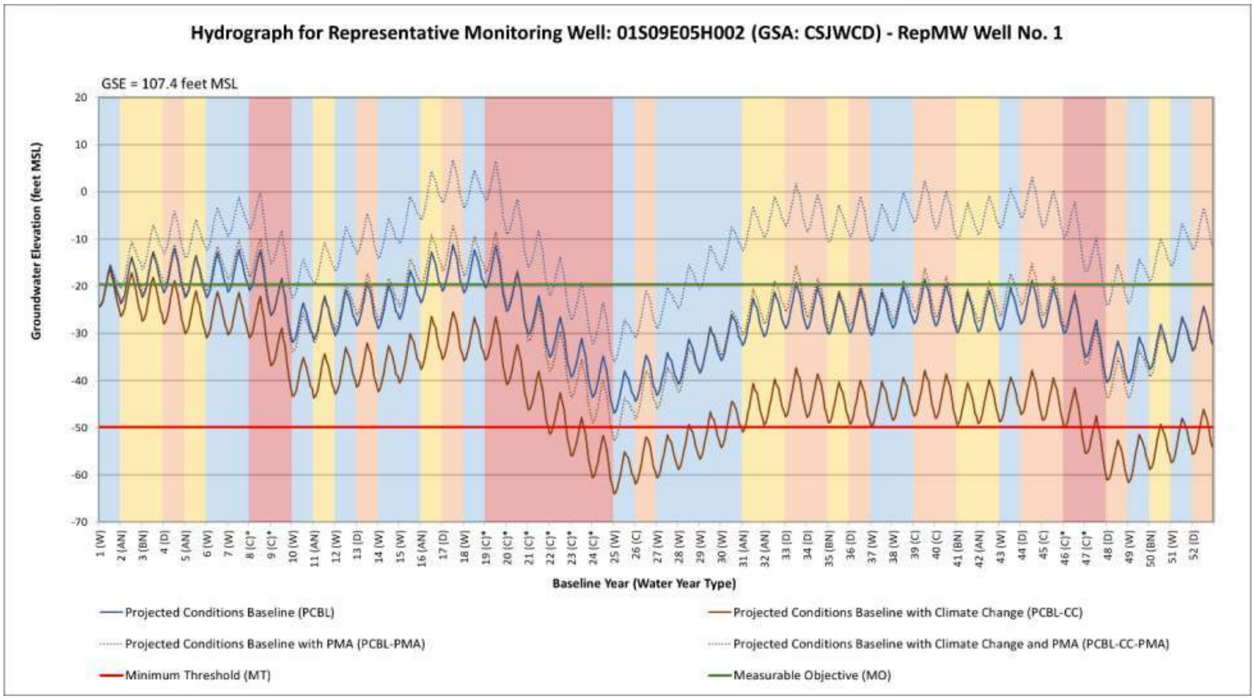


Figure C-3: Groundwater Level Hydrograph for Well 01N07E14J002

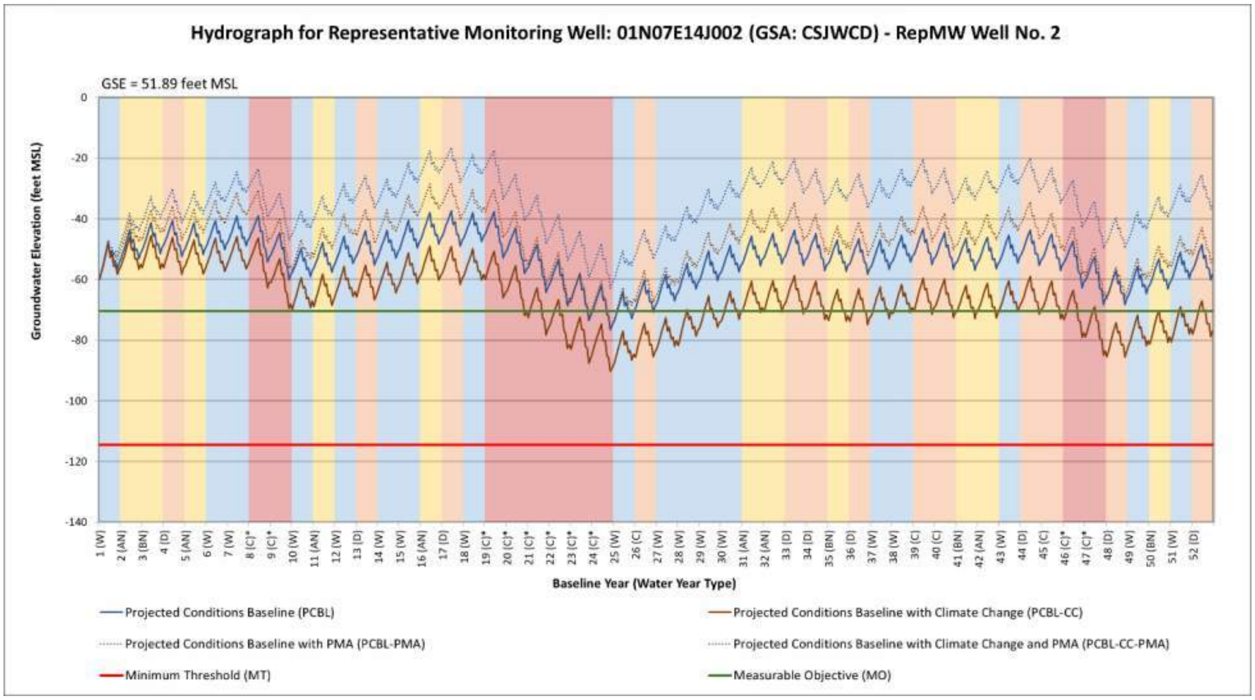


Figure C-4: Groundwater Level Hydrograph for Well Swenson-3

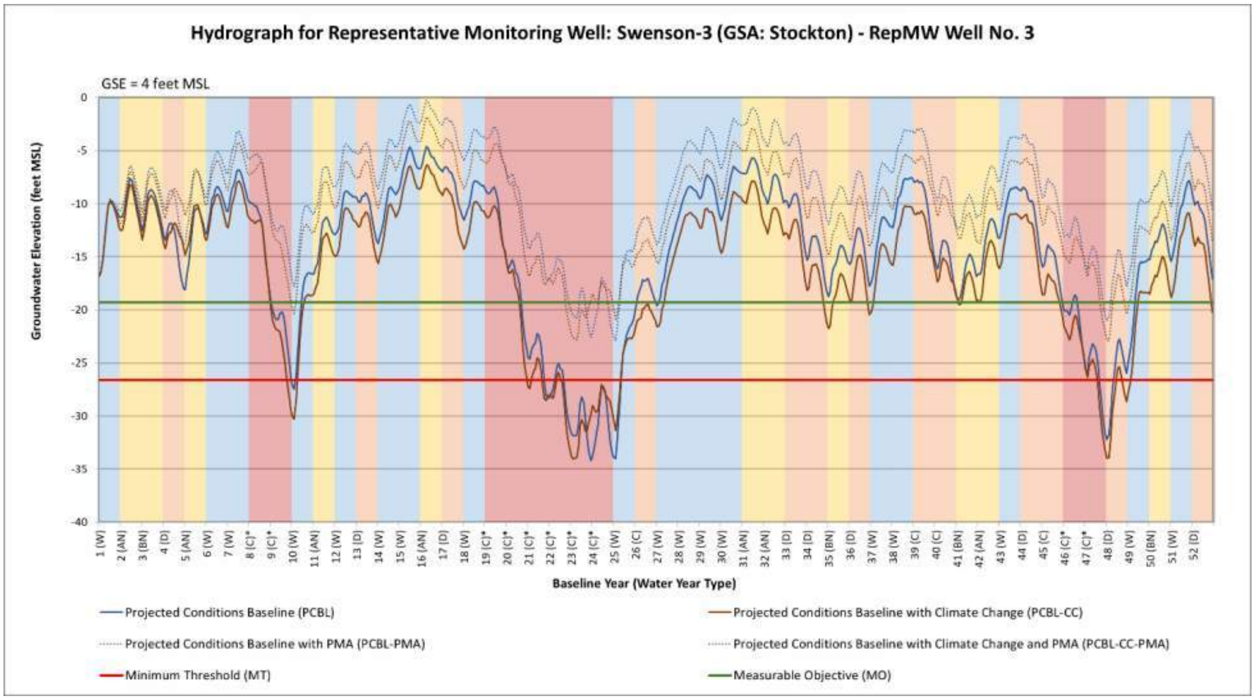


Figure C-5: Groundwater Level Hydrograph for Well 02N08E15M002

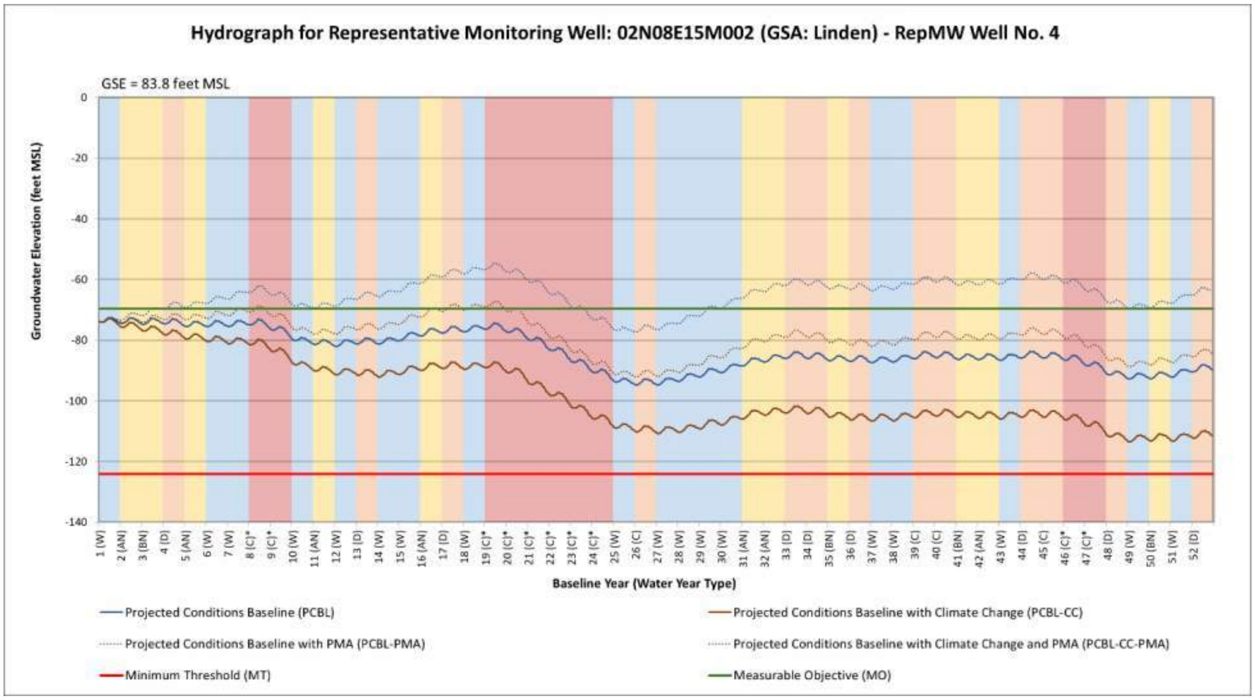


Figure C-6: Groundwater Level Hydrograph for Well #3 Bear Creek

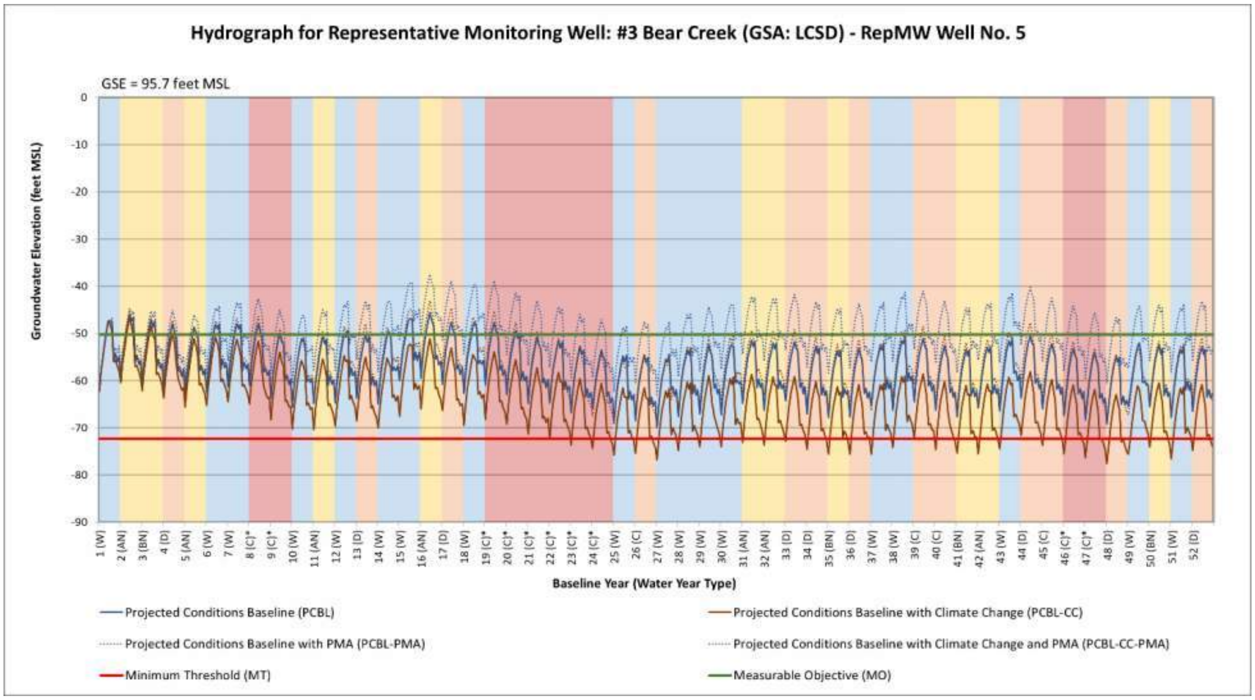


Figure C-7: Groundwater Level Hydrograph for Lodi City Well #2

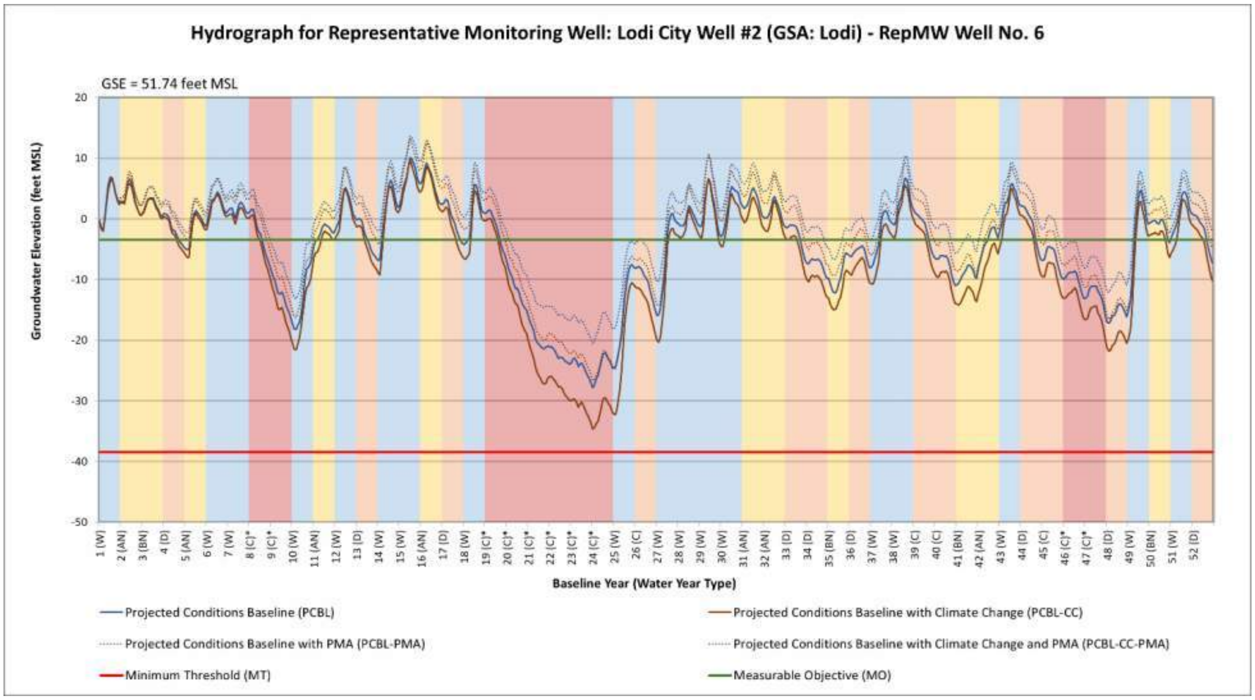


Figure C-8: Groundwater Level Hydrograph for Well 18

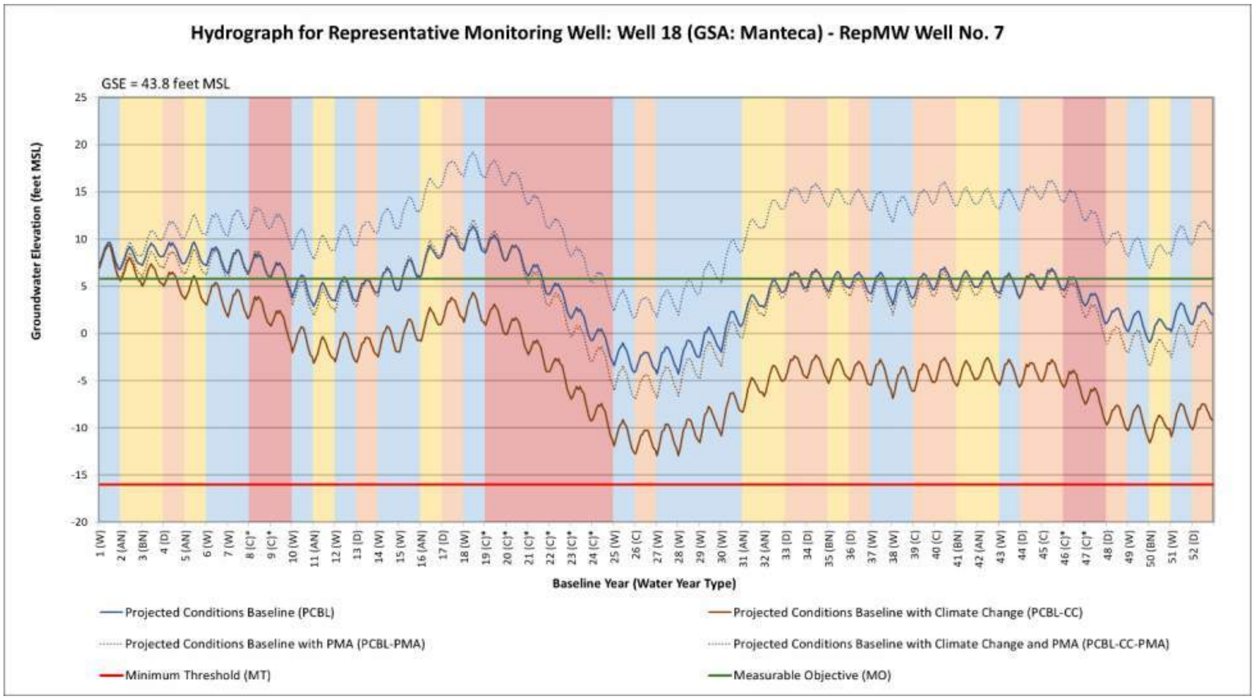


Figure C-9: Groundwater Level Hydrograph for Well 04N07E20H003M

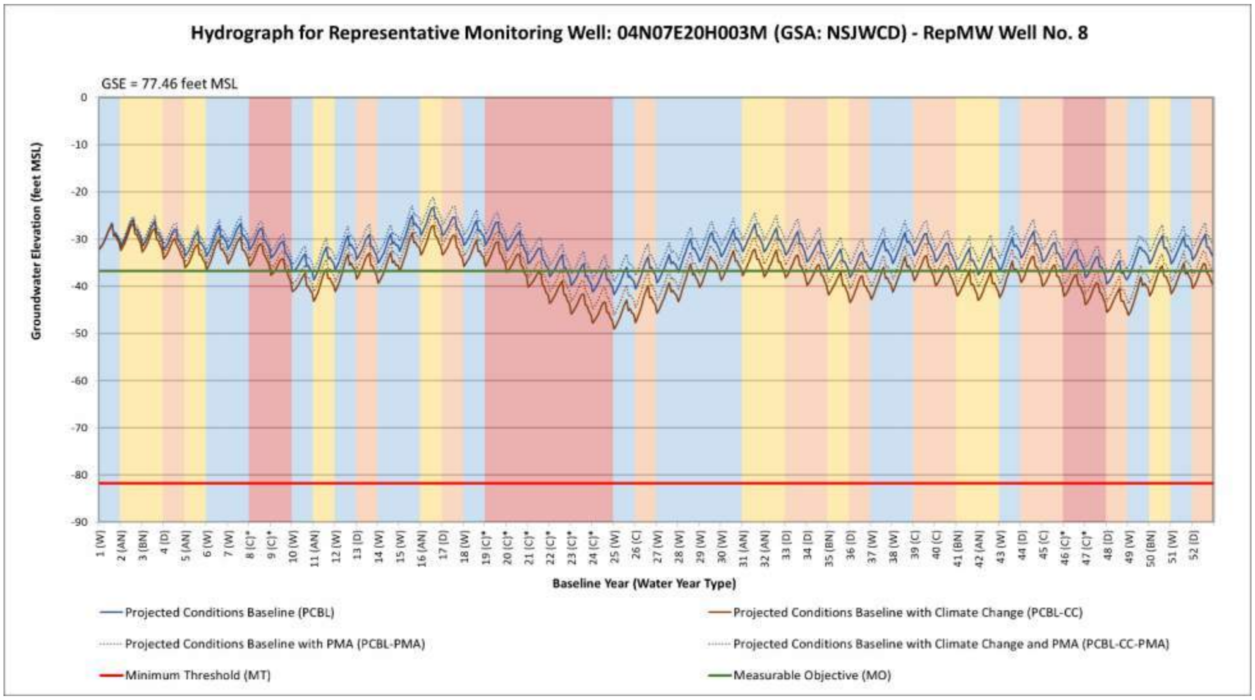


Figure C-10: Groundwater Level Hydrograph for Well 03N07E21L003

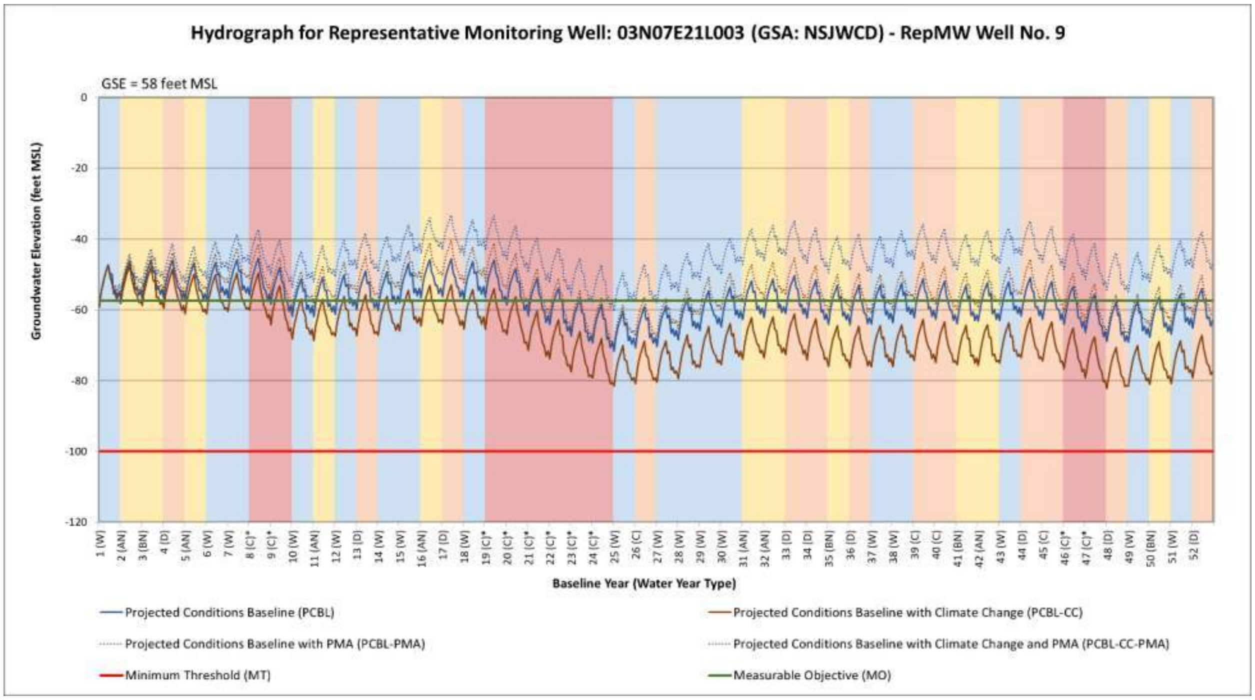


Figure C-11: Groundwater Level Hydrograph for Well Hirschfeld (OID8)

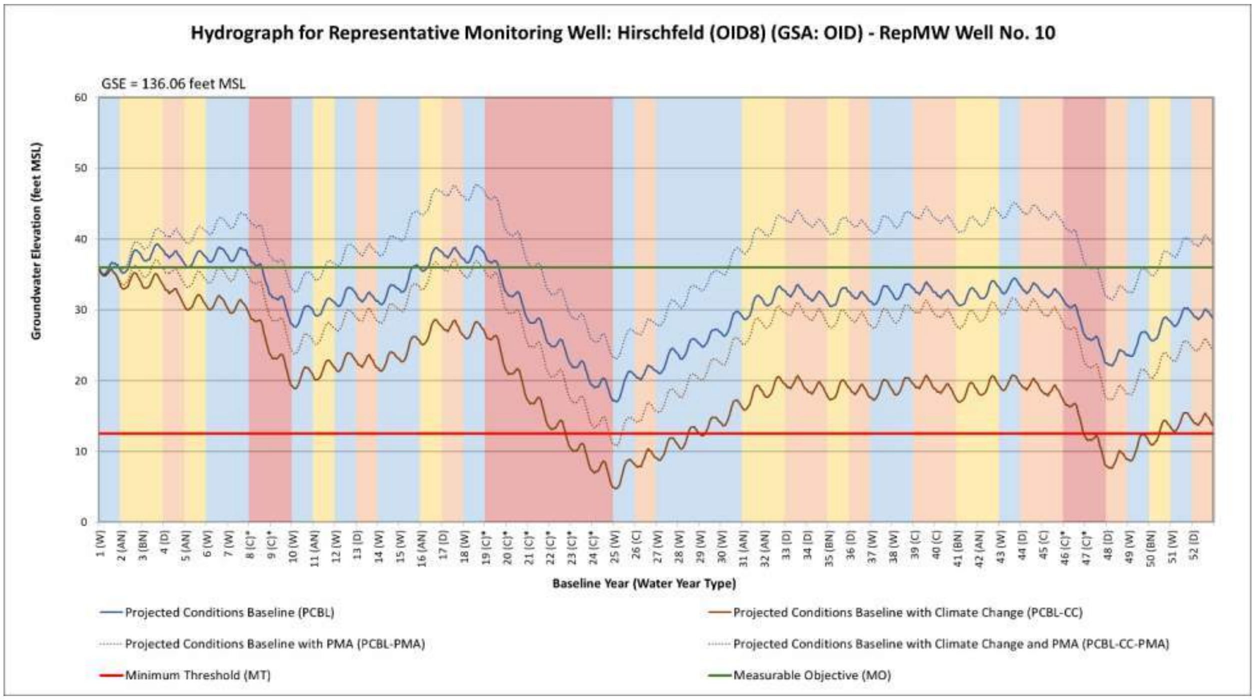


Figure C-12: Groundwater Level Hydrograph for Well Burnett (OID4)

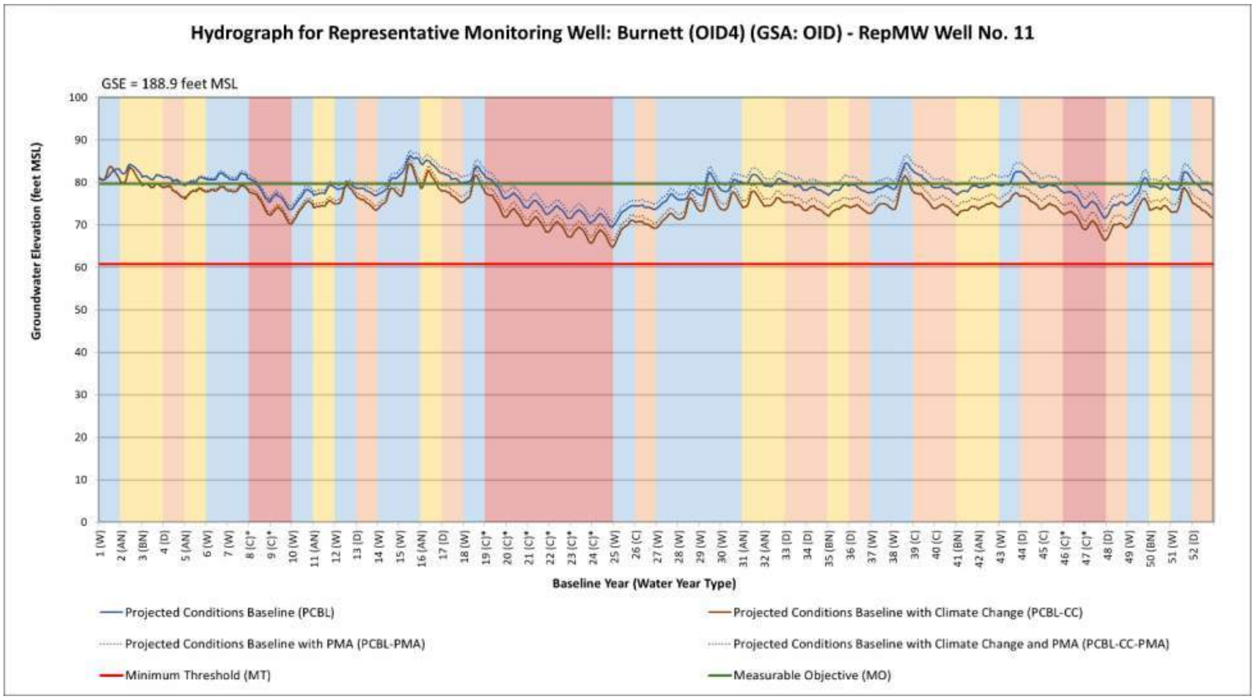


Figure C-13: Groundwater Level Hydrograph for Well 02S07E31N001

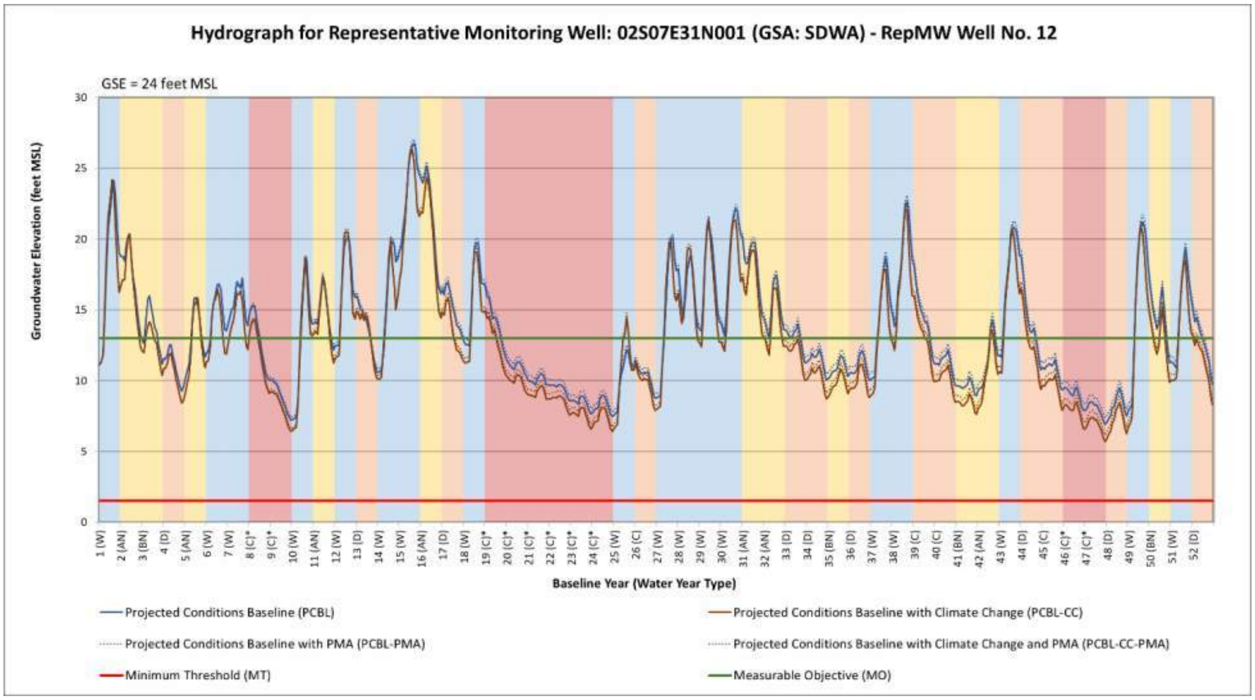


Figure C-14: Groundwater Level Hydrograph for Well 02S08E08A001

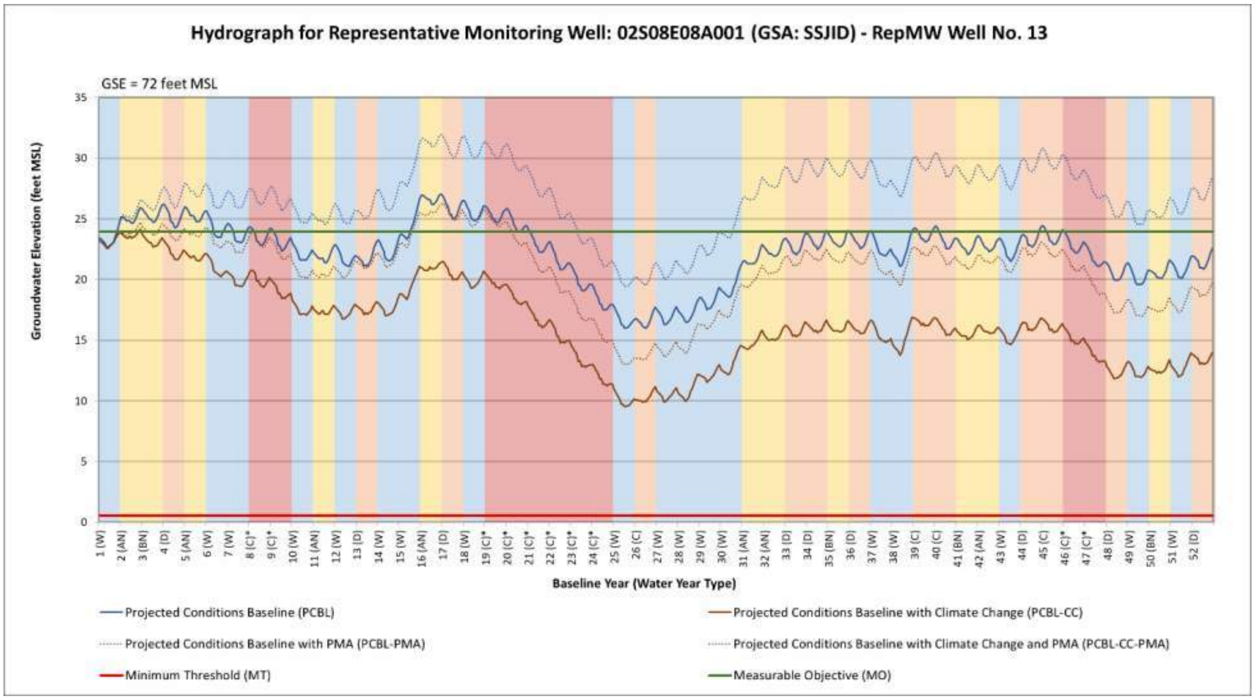


Figure C-15: Groundwater Level Hydrograph for Well 02N07E03D001

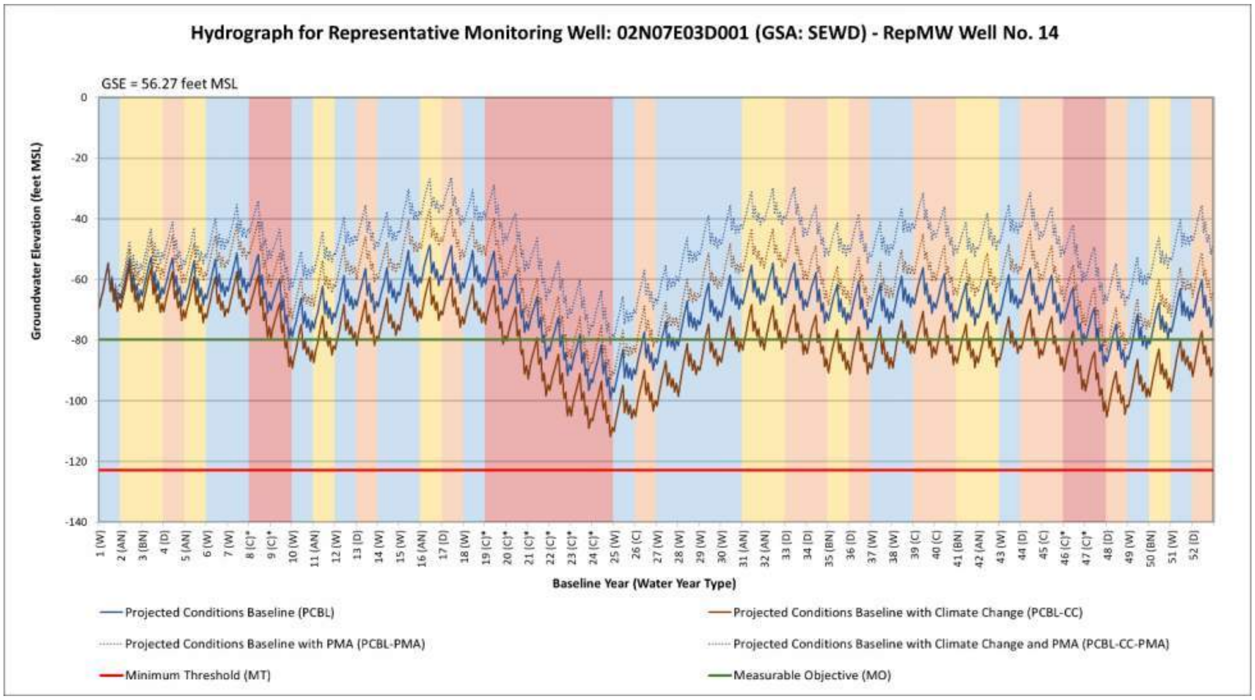


Figure C-16: Groundwater Level Hydrograph for Well 01N09E05J001

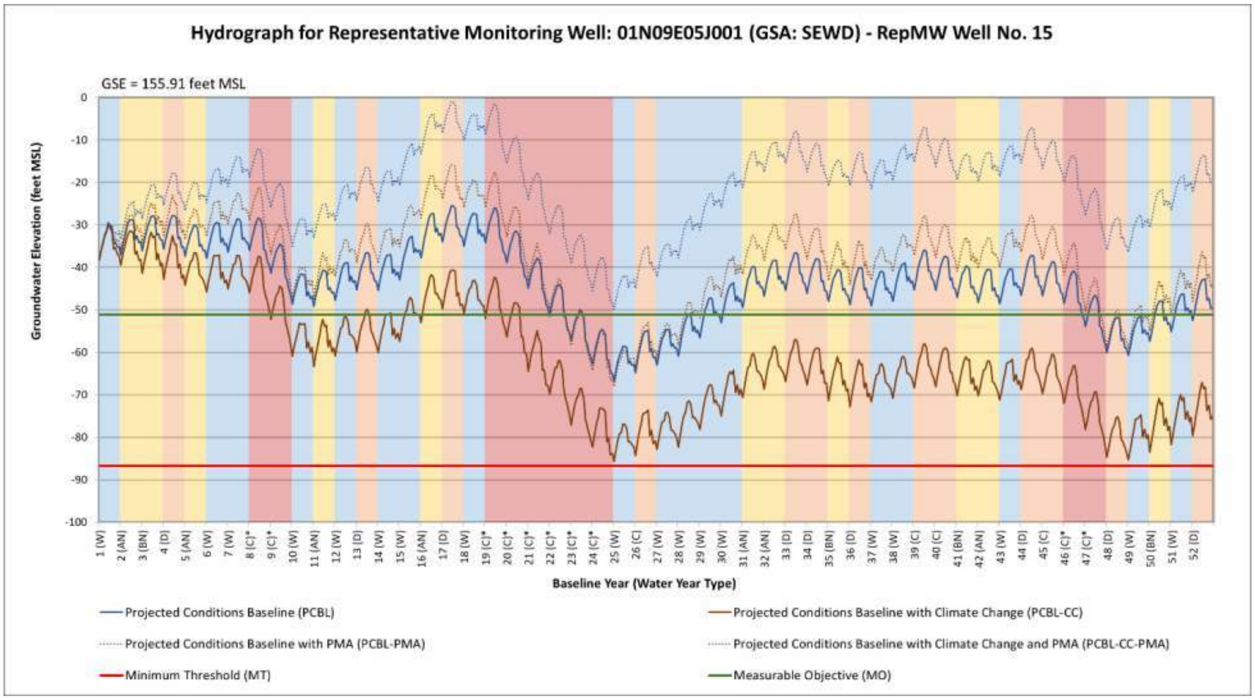


Figure C-17: Groundwater Level Hydrograph for Well 02N07E29B001

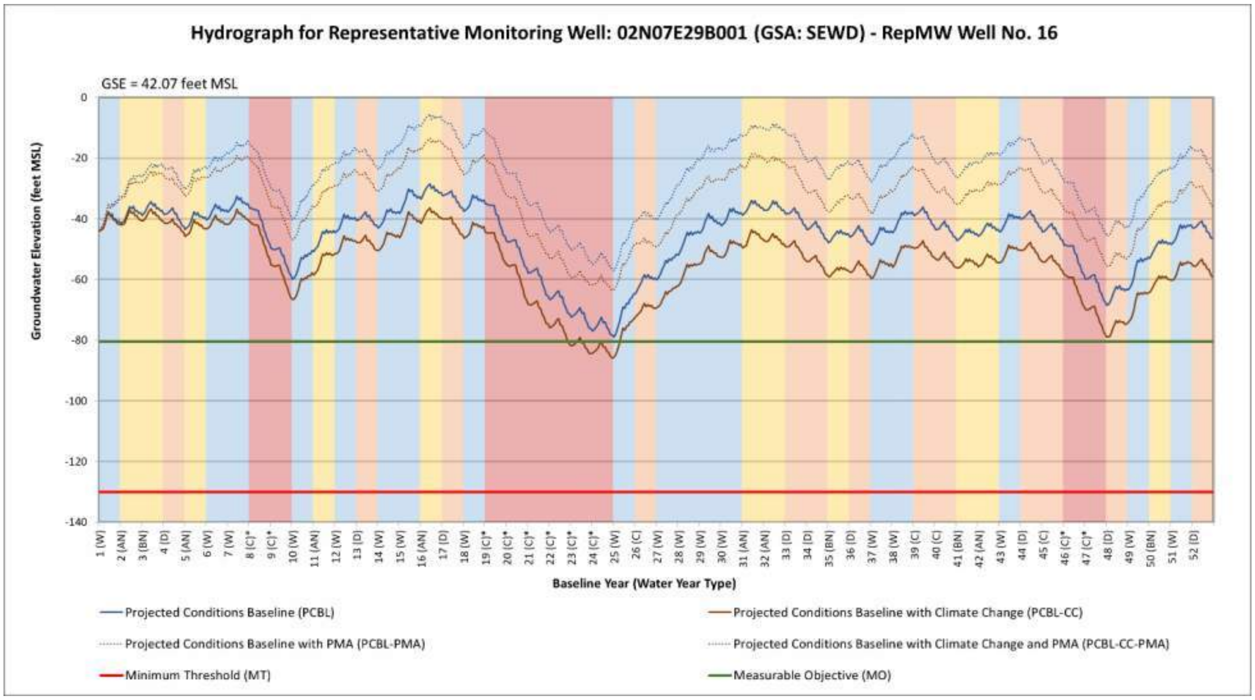


Figure C-18: Groundwater Level Hydrograph for Well 04N05E36H003

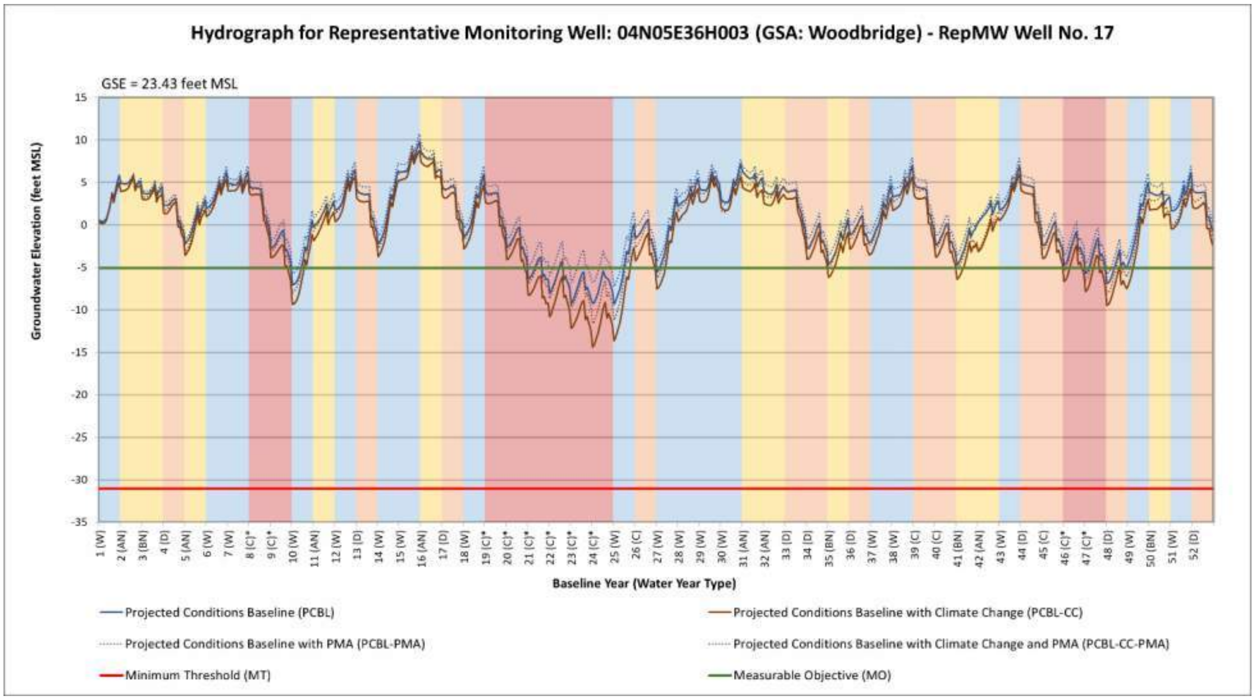


Figure C-19: Groundwater Level Hydrograph for Well 03N06E05N003

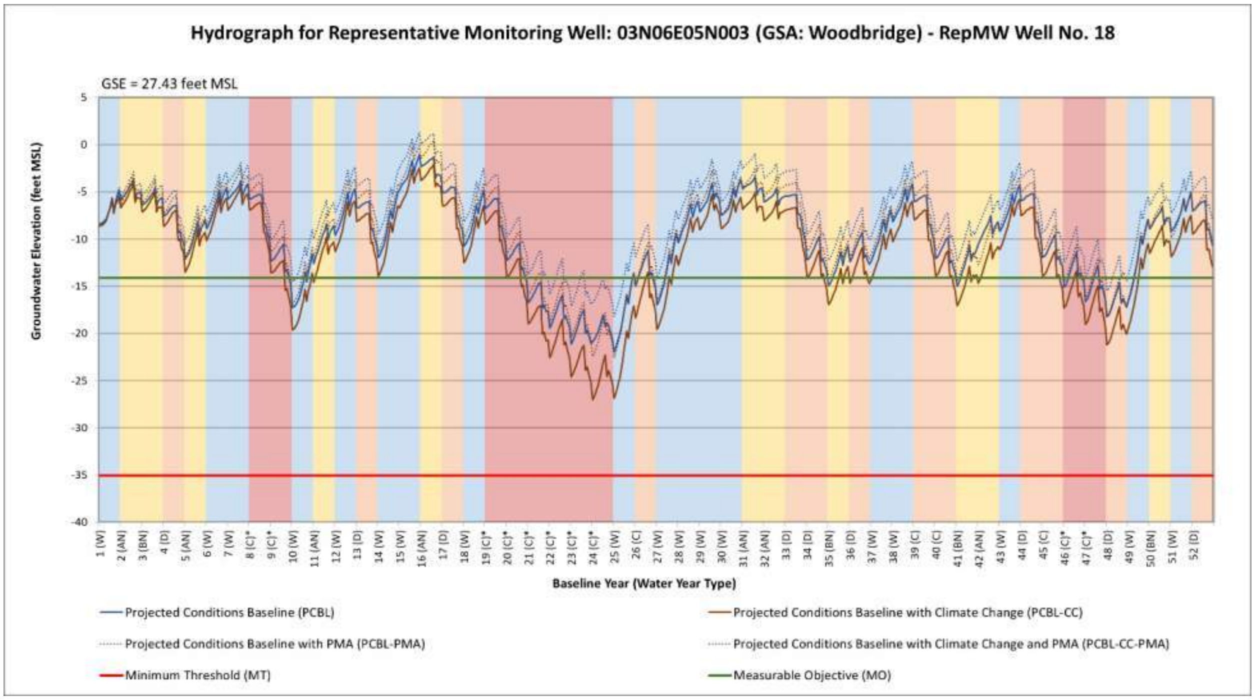


Figure C-20: Groundwater Level Hydrograph for Well 04N05E24J004

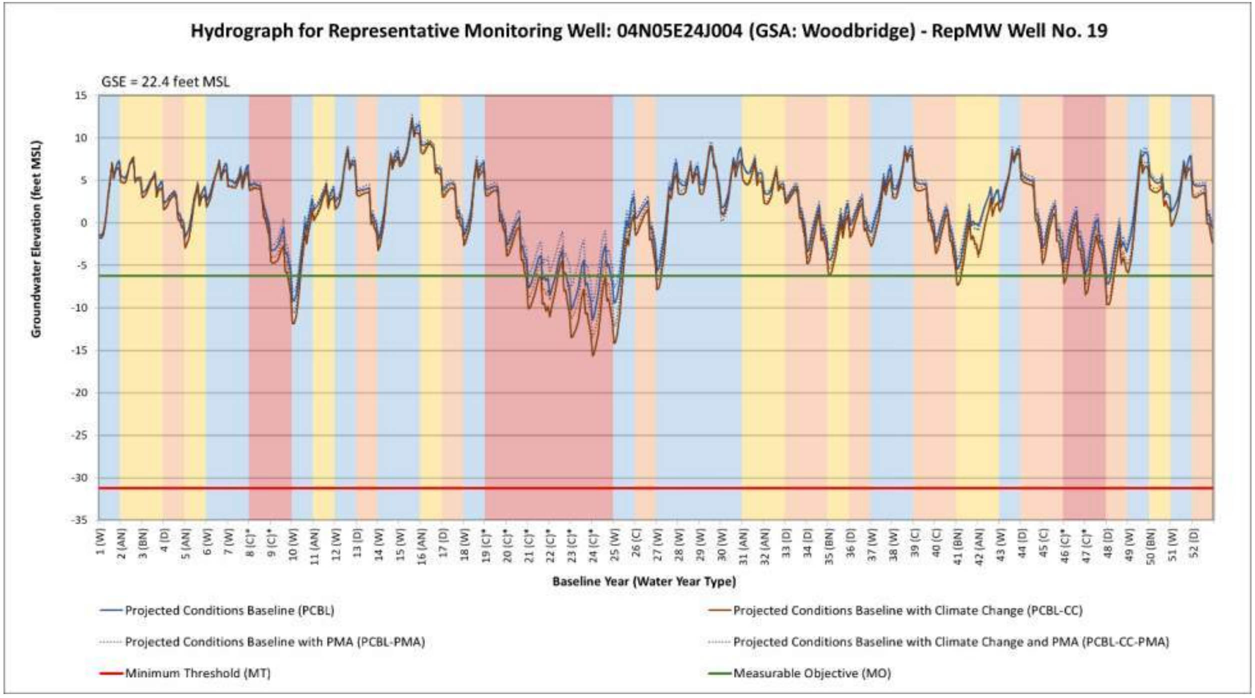


Figure C-21: Groundwater Level Hydrograph for Well 01S10E26J001M

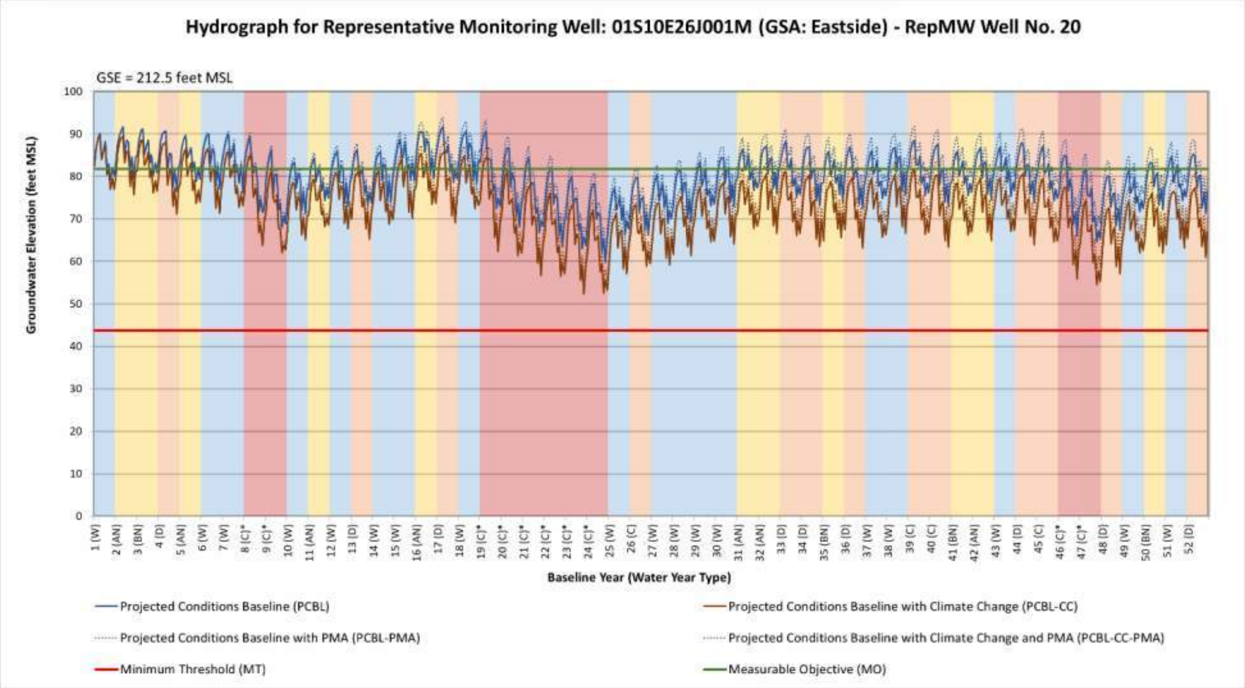
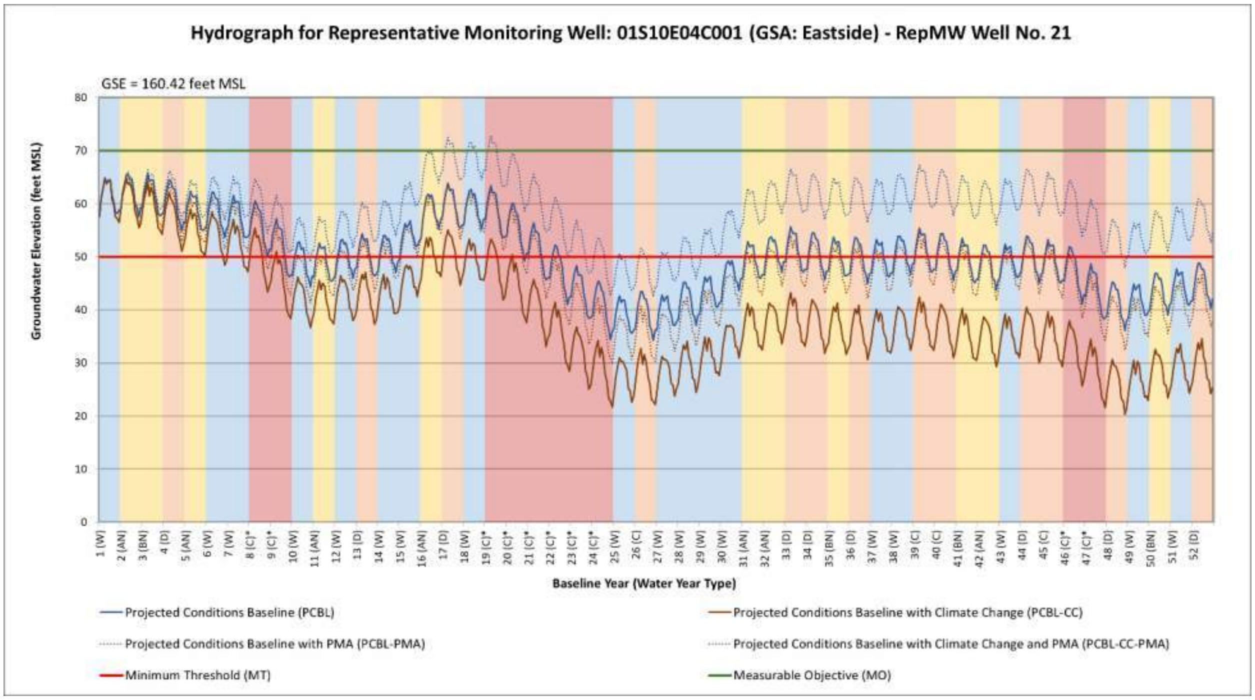


Figure C-22: Groundwater Level Hydrograph for Well 01S10E04C001



ATTACHMENT 3 – ESJWRM Version 2.0 Update

Eastern San Joaquin
Water Resources Model
(ESJWRM)
Version 2.0 Update

Prepared for:
Eastern San Joaquin Groundwater Authority

UPDATED DRAFT

June 2, 2022

Table of Contents

SECTION **PAGE NO.**

Tables

Figures

Appendices

1 Historical Calibration Update

The Eastern San Joaquin Water Resources Model (ESJWRM) was developed primarily to evaluate the current and recent historical groundwater conditions of the Eastern San Joaquin Groundwater Subbasin (ESJ Subbasin or Subbasin) and simulate various current and future condition scenarios as part of the Groundwater Sustainability Plan (GSP) preparation process under the Sustainable Groundwater Management Act (SGMA) (Woodard & Curran, 2018a). The fine geographic scale of the model provides the opportunity for individual Groundwater Sustainability Agencies (GSAs) to evaluate the effect of changing ESJ Subbasin conditions on smaller GSA areas. The Eastern San Joaquin Groundwater Authority (ESJGWA) was formed by a Joint Powers Agreement (JPA) and coordinates the SGMA activities for the Subbasin. The ESJGWA members include the 16 GSAs in the Subbasin.

ESJWRM uses the Integrated Water Flow Model (IWFM-2015) platform, has a finite element grid, includes data on a monthly time step, and covers the area of Cosumnes Subbasin, Eastern San Joaquin Subbasin, Modesto Subbasin, and the portion of the City of Lathrop east of San Joaquin River in the Tracy Subbasin. The original development of ESJWRM was from 2016 through 2018, with application of ESJWRM to GSP development occurring from 2018 through 2020 and resulting in a November 2019 GSP (ESJGWA, 2019). The GSP version of the ESJWRM (ESJWRM Version 1.1), which covers Water Years (WY) 1995 through 2015 (October 1994 through September 30, 2015), was documented in an August 2018 report (Woodard & Curran, 2018a) as well as a February 2018 technical memorandum (Woodard & Curran, 2018b). The earlier reports cover the development of the model, the model platform, the model framework, and all input data and results. This report serves as an update to the earlier model report (Woodard & Curran, 2018a) and only discusses portions of the model that were updated as part of the recent effort to develop ESJWRM Version 2.0, as well as a complete discussion of updated model results. This section includes all the updates made to ESJWRM Version 2.0.

1.1 Model Code and Data Updates Since the Groundwater Sustainability Plan

Since the ESJ Subbasin GSP was finalized in November 2019, the ESJWRM has undergone three updates:

1. Extension of Data from Water Year 2016 through Water Year 2019
2. Extension of Data through Water Year 2020
3. Full Model Update and Recalibration (resulting in ESJWRM Version 2.0)

The first two updates were completed as part of the preparation of ESJ Subbasin GSP annual reports to the Department of Water Resources (DWR). These updates only included an extension of model time series data (i.e., land use, surface water diversions, groundwater well pumping, and urban demand) and the model provided estimates of total surface water supplies, groundwater pumping, and change in groundwater storage for the water year covered by the model report. The third and major update is the focus of this report and the majority of the work was performed in 2021. Through discussions with GSAs near the completion of the GSP, several areas for update and refinement in the ESJWRM were identified. The goals of the 2021 model update to ESJWRM Version 2.0 were to:

1. Confirm the data in the ESJWRM is the latest hydrologic, water supply, and operations data available. This includes updating issues identified through discussions with the GSAs as part of the GSP process and including newer data and techniques that were unavailable in the development of the original model.

2. Refine the model calibration to ensure a reasonable representation of the hydrologic conditions in the ESJ Subbasin with the updated data and observation information.
3. Update the projected conditions baseline to estimate conditions in the ESJ Subbasin at buildout (approximately 2040) without GSP projects and potential climate change conditions. This update is discussed in Section 2.
4. Use the updated ESJWRM versions to develop water budgets at the GSA level to understand the water operations for each GSA to support a water accounting framework and assessment of benefits and impacts of sustainability actions at the GSA level. This is discussed in Section **Error! Reference source not found.**.

The data update was completed through extensive outreach to GSAs and Subbasin agencies and coordination with the ESJGWA Technical Advisory Committee (TAC), including meeting presentations and interaction with stakeholders. Data for the model update included a variety of agencies and GSAs. Below is a list of the agencies that provided data and input on the model update:

Agricultural Water Purveyors

- Calaveras County Water District (CCWD)
- Central San Joaquin Water Conservation District (CSJWCD)
- North San Joaquin Water Conservation District (NSJWCD)
- Oakdale Irrigation District (OID)
- South San Joaquin Irrigation District (SSJID)
- Stockton East Water District (SEWD)
- Woodbridge Irrigation District (WID)

Municipal Water Purveyors

- California Water Service Company Stockton District (Cal Water)
- City of Escalon
- City of Lodi
- City of Manteca
- City of Ripon
- City of Stockton
- Linden County Water District (LCWD)
- Lockeford Community Services District (LCSD)
- Stockton East Water District (SEWD)

For the update to ESJWRM Version 2.0, more extensive coordination was appreciated from the following people:

- Eric Houston (City of Stockton)
- Justin Hopkins (SEWD)

- Mike Henry (LCSD)
- Dave Fletcher (LCWD)
- Alan Nakanishi and Travis Kahrs (City of Lodi)
- Jennifer Spaletta (NSJWCD)
- Eric Thorburn and Emily Sheldon (OID)
- Brandon Nakagawa (SSJID)
- Matt Zidar and Glenn Prasad (San Joaquin County)

1.1.1 IWFM Version

The model platform, IWFM-2015, has had several updates since ESJWRM Version 1.1 was originally developed and the IWFM code has been updated to the latest release version (IWFM-2105 Version 1273) for ESJWRM Version 2.0. New IWFM versions typically include error fixes and larger code changes that may impact the underlying calculations and therefore model results. Changes between model versions are documented on DWR's IWFM website (https://water.ca.gov/Library/Modeling-and-Analysis/Modeling-Platforms/Integrated-Water-Flow-Model) and the latest IWFM technical memorandums are available online (Dogrul and Kadir, 2021a and 2021b).

1.1.2 Updated Data from the ESJWRM version used in the Stanislaus River Basin Plan

A modified version of ESJWRM Version 1.1 was prepared as part of the Stanislaus River Basin Plan. The Stanislaus River Basin Plan, a collaborative effort by Oakdale Irrigation District (OID) and South San Joaquin Irrigation District (SSJID), is still in draft format and is discussed in the respective agricultural water management plans (AWMP) (OID, 2021) (SSJID, 2021). The changes made to the modified version of ESJWRM Version 1.1 were incorporated into the 2021 update to ESJWRM Version 2.0. The changes were focused on Modesto Subbasin and OID, both in ESJ Subbasin and in Modesto Subbasin. Changes included updating agricultural and urban pumping in Modesto Subbasin, surface water diversion and groundwater pumping time series, surface water diversion and groundwater pumping delivery areas for OID and Modesto Subbasin agencies, target soil moisture percentage, agricultural return flow fraction, and Modesto Reservoir seepage. Changes to the Modesto Subbasin are not discussed in detail in the sections below.

1.1.3 Hydrologic Period

The updated ESJWRM Version 2.0 simulates water years 1995 through 2020 (October 1, 1994 through September 30, 2020). It was extended five water years from ESJWRM Version 1.1. Due to the extension of the period covered by the model, all model data with monthly or annual values had to be extended. These updates are listed in the sections below.

1.1.4 Precipitation

As with ESJWRM Version 1.1, rainfall data for the model area is derived from the PRISM (Precipitation-Elevation Regressions on Independent Slopes Model) database used in the DWR's CALSIMETAW (California Simulation of Evapotranspiration of Applied Water) model. The database contains daily precipitation data from October 1, 1921 on a 4-kilometer grid throughout the model area (OSU, 2021). ESJWRM has monthly rainfall data defined for every model element and adjacent foothill watershed in order to preserve the spatial distribution of the monthly rainfall. Each of the model elements was mapped to the nearest of 364 available

PRISM reference nodes, uniformly distributed across the model domain. ESJWRM Version 2.0 includes the mapped precipitation time series for water years 2016 through 2020.

1.1.5 Land Use and Cropping Patterns

ESJWRM Version 2.0 utilizes the same land use categories as ESJWRM Version 1.1 as documented in the earlier reports (Woodard & Curran, 2018a and 2018b). The data through water year 2015 is the same as ESJWRM Version 1.1, except for minor tweaks to land use around the Subbasin’s two smallest GSAs, Lockeford Community Services District (LCSD) and Linden County Water District (LCWD). Due to the small size of these GSAs, model elements did not exactly align with GSA boundaries, so agricultural land use associated with the surrounding districts, North San Joaquin Water Conservation District (NSJWCD) for LCSD and Stockton East Water District (SEWD) for LCWD, was included in elements representing these two small urban communities. In discussions with the GSAs, it was agreed that the agricultural land use would be removed from model elements assigned to LCSD (15 elements) and LCWD (5 elements). In total, this edit impacted an average of 250 acres per year.

DWR released a statewide crop mapping for 2016 that was completed using remote sensing methods to collect and process the data at the parcel scale and was then ground truthed for a high overall accuracy (DWR, 2016). This spatial land use data was mapped to ESJWRM model elements and assumed to represent land use for all extended water years (2016 through 2020). Based on discussions with SSJID and comparison with the most recent AWMP (SSJID, 2021), the 2016 land use for SSJID was replaced with the data for 2015 from ESJWRM Version 1.1.

Figure 1: 2016 Land Use

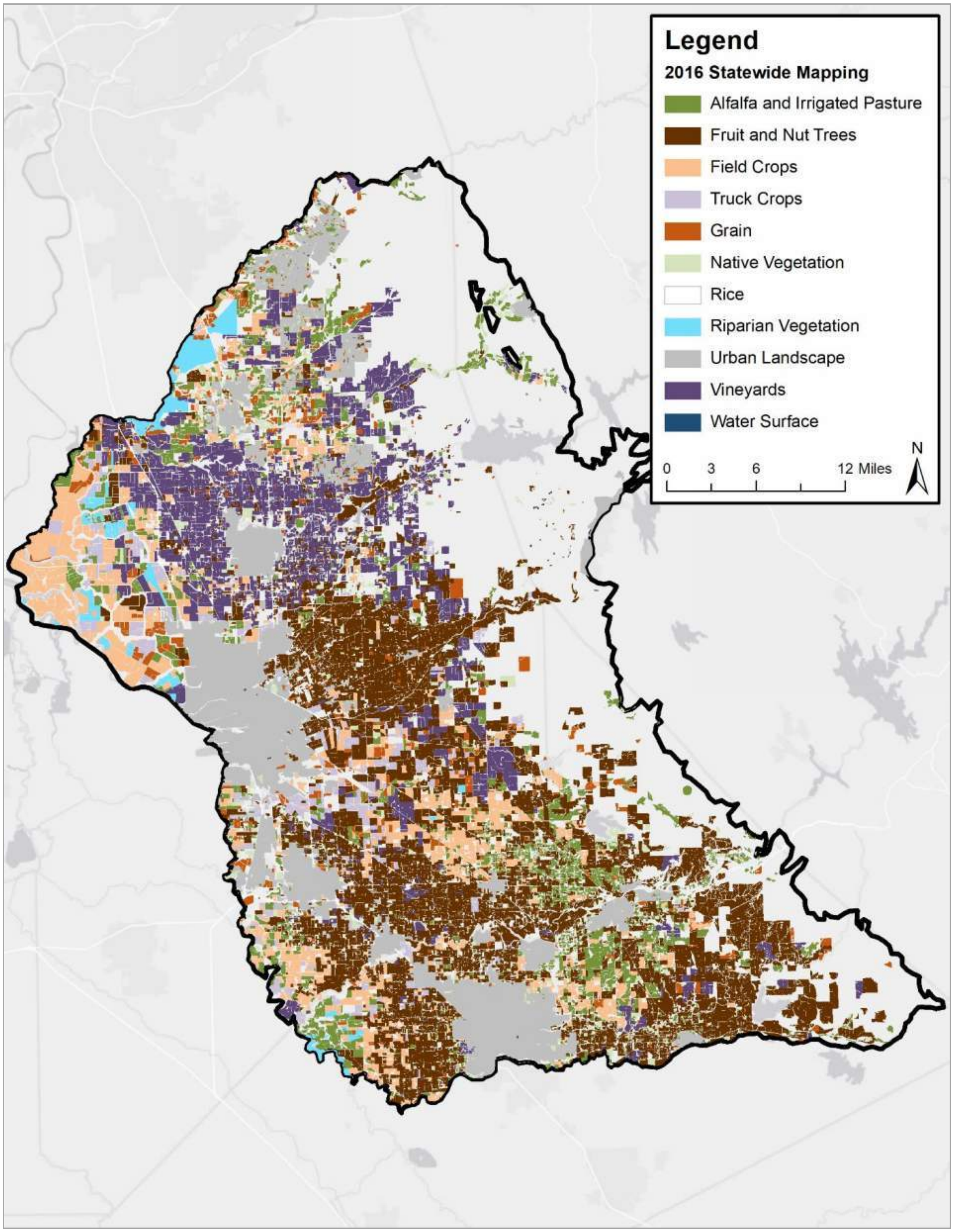
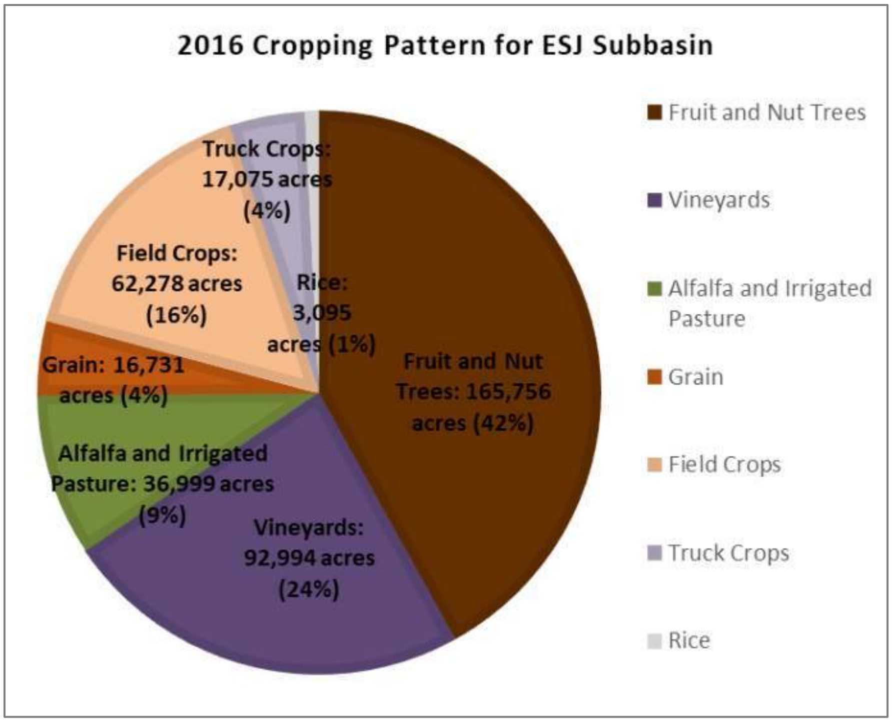


Figure 2: 2016 Cropping Pattern for ESJ Subbasin



1.1.6 Stream Inflow

Stream inflows to the model were extended using updated data from United States Geological Survey (USGS) stream gages and the United States Army Corps of Engineers (USACE) reservoir releases. Dry Creek, with data estimated using a regression after January 1998, was updated using recent monthly averages for similar water year types. A column was added for SSJID system outflows to Stanislaus River, discussed further in Section 1.1.11 below. A table of stream input data may be found in Table 1.

Table 1: Summary of ESJWRM Stream Inflow Data

Stream	Stream Node	Source	Gage Name	Period of Record	Average Annual Streamflow (acre-feet)
Cosumnes River	1	USGS	USGS 11335000: Cosumnes River at Michigan Bar, CA	October 1907 to present/ongoing	397,000
Dry Creek	140	USGS	Estimated in C2VSim by correlation with USGS 11329500: Dry Creek near Galt, CA	Not continuous October 1926 to December 1997	29,000
		USGS	Estimated in C2VSim by correlation with USGS 11335000: Cosumnes River at Michigan Bar, CA	Used October 1987 to September 1995 and January 1998 to September 2015	

Stream	Stream Node	Source	Gage Name	Period of Record	Average Annual Streamflow (acre-feet)
		n/a	Average of Historical Data by Month and Water Year Type	Used October 2015 to present/ongoing	
Mokelumne River	290	USGS	USGS 11323500: Mokelumne River below Camanche Dam, CA	October 1904 to present/ongoing	562,000
Calaveras River	758	USGS	USGS 11308900: Calaveras River below New Hogan Dam near Valley Springs, CA	February 1961 to September 1990	160,000
		USACE	New Hogan Dam releases	October 1990 to present/ongoing	
Stanislaus River	1033	USGS	USGS 11302000: Stanislaus River below Goodwin Dam near Knights Ferry, CA	February 1957 to present/ongoing	576,000
Tuolumne River	1248	USGS	USGS 11289650: Tuolumne River below Lagrange Dam near Lagrange, CA	October 1970 to present/ongoing	905,000
San Joaquin River	1497	USGS	USGS 11303500: San Joaquin River near Vernalis, CA	October 1923 to present/ongoing	3,162,000
SSJID System Outflows to Stanislaus River	1212	SSJID	n/a	n/a	24,000

1.1.7 Boundary Conditions

The boundary conditions in the model remain the same as ESJWRM Version 1.1, with eastern flows from the Sierra Nevada Mountains simulated in the model as small watersheds, Camanche Reservoir seepage estimated using a constrained general head boundary condition, Woodward Reservoir and Modesto Reservoir seepage represented as stream diversions, flows from outside of the model area represented with general head boundary conditions, and groundwater levels at or near zero near the edges of the Sacramento-San Joaquin Delta are represented using specified head boundary conditions.

Data was extended through water year 2020 using a monthly average by water year type. Data for water years 2010 through 2015 were recalculated and updated in the model. The heads near the Delta were adjusted based on analysis of nearby observed groundwater levels.

1.1.8 Urban Demand

Urban demand, comprised of annual population and monthly per capita water use (PCWU), is specified for incorporated urban areas or communities and estimated for rural urban demand. Changes to ESJWRM Version 1.1 were to add specified urban areas for Jenny Lind (in Calaveras County with a portion of the city outside of ESJ Subbasin) and in Modesto Subbasin (Oakdale, Riverbank, Waterford, and Modesto). City of Stockton, which was previously separated into portions for City of Stockton and California Water Service Company Stockton District (Cal Water), was updated to separate out the areas of unincorporated San Joaquin County land from City of Stockton. All urban areas were reviewed and updated to match areas where urban surface water deliveries and urban groundwater pumping was supplied. Urban surface water supply is assumed to have both indoor and outdoor usage, of which excess outdoor use returns to the model streams or percolates into the groundwater system.

Updated population for water years 2016 through 2020 using data from the California Department of Finance (DOF, 2021). The population for the entire Stockton area was updated for the entire model simulation period to data from the California Department of Finance. Based on review by LCSD, LCSD population for the entire model simulation period was updated using historical population and population projections in the 2016 LCSD Municipal Services Review (LCSD, 2016). The rural population, or people not in incorporated areas, was estimated by calculating an estimate of the rural population per acre in San Joaquin County and applying that population estimate to the unincorporated acreage of the model.

Urban demand was calculated for each area as the sum of the surface water (if the agency received surface water) and the groundwater pumping. The updated water supply is discussed in the sections below for surface water (Section 1.1.9) and groundwater (Section 1.1.1). The PCWU was then calculated for each agency as the monthly calculated demand divided by the annual population. Calculating the PCWU directly from the supplied water mitigates issues with urban surplus or shortage in the land and water use budget.

1.1.9 Surface Water Diversions

Surface water diversions were fully reorganized and renumbered in ESJWRM Version 2.0 and many additional diversions were included that were not in ESJWRM Version 1.1. Diversion edits included splitting NSJWCD's agricultural diversion from Mokelumne River into two time series for the NSJWCD north and south service areas; including NSJWCD recharge projects; refinement of NSJWCD recharge and irrigation schedules; adjustments to Lodi's data; adding the urban delivery of Calaveras River water from Calaveras County Water District (CCWD) to Jenny Lind (assuming 43% of Jenny Lind lies within ESJ Subbasin); updating OID north and south and SSJID deliveries to better represent what the AWMPs report for farm deliveries, recycled water deliveries, annual contract deliveries, and canal and drain seepage; separating urban deliveries to City of Stockton area into separate time series for City of Stockton, Cal Water, and San Joaquin County users in City of Stockton; separating SEWD diversion losses from Calaveras and Stanislaus Rivers into separate time series; additional diversions to Modesto Subbasin included as part of model refinements for the Stanislaus River Basin Plan; and the update of surface water delivery estimates for areas of the Delta and riparian user areas along the rivers.

All GSAs were provided all model historical supply data to review and update during the development of ESJWRM Version 2.0. Additionally, all surface water diversion delivery groups were reviewed and updated to reflect a more recent understanding of Subbasin surface water operations. A summary of diversions simulated in the model is provided in Table 2, along with fractions for recoverable loss (i.e., percolation or canal seepage), non-recoverable loss (i.e., evaporation), and delivery (i.e., amount delivered is equal to the total amount minus the recoverable and non-recoverable losses). ESJWRM Version 2.0 includes 66 diversions, 61 of which are listed in Table 2 and 5 diversions that are placeholders that are not currently being used in the model. The Projected Conditions Baseline Version 2.0 averages are also included in Table 2 and are discussed in Section 2.1.3.

Table 2: Summary of ESJWRM Surface Water Deliveries

ID	Description	Diversion Location	Delivery Area	Primary Use	Fraction			ESJWRM Version 2.0 Average Annual Diversion*** (acre-feet)	PCBL Version 2.0 Average Annual Diversion*** (acre-feet)	Data Source
					RL*	NL**	Delivery			
1	Mokelumne River to North San Joaquin WCD North System for Ag	Mokelumne River	North San Joaquin WCD North System	Ag	50%	0%	50%	360	0	NSJWCD
2	Mokelumne River to North San Joaquin WCD South System for Ag	Mokelumne River	North San Joaquin WCD South System	Ag	50%	0%	50%	1,900	2,000	NSJWCD
3	Mokelumne River to North San Joaquin WCD for CALFED GW Recharge Project	Mokelumne River	CALFED GW Recharge Project	Recharge	100%	0%	0%	260	800	NSJWCD
4	Mokelumne River to North San Joaquin WCD For Tracy Lake Recharge Project	Mokelumne River	Tracy Lake Recharge Project	Recharge	50%	0%	50%	320	3,200	NSJWCD
5	Mokelumne River to City of Lodi (by agreement with Woodbridge ID) for M&I	Mokelumne River	City of Lodi	Urban	0%	0%	100%	5,500	4,700	Lodi
6	Mokelumne River to City of Lodi (by agreement with NSJWCD) for M&I	Mokelumne River	City of Lodi	Urban	0%	0%	100%	370	0	Lodi

ID	Description	Diversion Location	Delivery Area	Primary Use	Fraction			ESJWRM Version 2.0 Average Annual Diversion*** (acre-feet)	PCBL Version 2.0 Average Annual Diversion*** (acre-feet)	Data Source
					RL*	NL**	Delivery			
7	Mokelumne River to City of Lodi (banked from agreement with WID) for M&I	Mokelumne River	City of Lodi	Urban	0%	0%	100%	560	0	Lodi
8	Mokelumne River to Woodbridge ID for Ag	Mokelumne River	Woodbridge Irrigation District	Ag	30%	2%	68%	58,800	44,200	WID
9	Mokelumne River Export to Contra Costa WD (by agreement with Woodbridge ID)	Mokelumne River	Export out of model	Urban	0%	0%	100%	2,000 (one year only)	0	WID
10	Mokelumne River to City of Stockton for Delta Water Supply Project (by agreement with Woodbridge ID) for M&I	Mokelumne River	City of Stockton	Urban	0%	0%	100%	7,700	10,500	City of Stockton
11	San Joaquin River at Empire Tract to City of Stockton for Delta Water Supply Project for M&I	San Joaquin River	City of Stockton	Urban	0%	0%	100%	8,500	21,600	City of Stockton
12	Calaveras River to Bellota Pipeline to Stockton East WD WTP for M&I	Calaveras River	Export out of model (imported in Diversions 14, 15, and 16)	Urban	0%	0%	100%	13,800	13,100	SEWD

ID	Description	Diversion Location	Delivery Area	Primary Use	Fraction			ESJWRM Version 2.0 Average Annual Diversion*** (acre-feet)	PCBL Version 2.0 Average Annual Diversion*** (acre-feet)	Data Source
					RL*	NL**	Delivery			
13	Stanislaus River at Goodwin Dam to Farmington Flood Control Basin to Lower Farmington Canal to Peters Pipeline to Stockton East WD WTP for M&I	Import (outside of ESJWRM)	Export out of model (imported in Diversions 14, 15, and 16)	Urban	0%	0%	100%	29,400	49,900	SEWD
14	Stockton East WD WTP to City of Stockton for M&I	Import (exported in Diversions 12 and 13)	City of Stockton	Urban	0%	0%	100%	18,800	5,100	UWMP
15	Stockton East WD WTP to Cal Water for M&I	Import (exported in Diversions 12 and 13)	Cal Water	Urban	0%	0%	100%	21,800	19,300	UWMP
16	Stockton East WD WTP to San Joaquin County in Stockton for M&I	Import (exported in Diversions 12 and 13)	San Joaquin County in Stockton	Urban	0%	0%	100%	1,400	1,500	UWMP
17	Calaveras River to Calaveras County WD for Ag	Import (outside of ESJWRM)	Calaveras County WD	Ag	9%	1%	90%	1,100	1,300	CCWD
18	Calaveras River to Jenny Lind for M&I	Import (outside of ESJWRM)	Jenny Lind	Urban	0%	0%	43%	1,800	1,800	CCWD

ID	Description	Diversion Location	Delivery Area	Primary Use	Fraction			ESJWRM Version 2.0 Average Annual Diversion*** (acre-feet)	PCBL Version 2.0 Average Annual Diversion*** (acre-feet)	Data Source
					RL*	NL**	Delivery			
19	Calaveras River to Stockton East WD for Ag	Calaveras River	Stockton East Water District	Ag	0%	0%	100%	23,600	21,100	SEWD
20	Calaveras River to Stockton East WD Losses	Calaveras River	Stockton East Water District, including canals	Recharge	89%	11%	0%	19,300	15,200	SEWD
21	Calaveras River to Farmington Groundwater Recharge Program	Calaveras River	Farmington Groundwater Recharge Program	Recharge	100%	0%	0%	1,400	5,200	SEWD
22	San Joaquin River to North Delta for Ag	San Joaquin River	North Delta Subregion	Ag	5%	1%	94%	139,600	125,800	Estimated by model
23	San Joaquin River to South Delta for Ag	San Joaquin River	South Delta Subregion	Ag	5%	1%	94%	26,700	18,500	Estimated by model
24	Stanislaus River at Goodwin Dam to Farmington Flood Control Basin to Lower Farmington Canal to Stockton East WD for Ag	Import (outside of ESJWRM)	Stockton East Water District	Ag	0%	0%	100%	4,400	6,800	SEWD
25	Stanislaus River to Stockton East WD Losses	Import (outside of ESJWRM)	Stockton East Water District, including canals	#N/A	88%	12%	0%	900	1,200	SEWD

ID	Description	Diversion Location	Delivery Area	Primary Use	Fraction			ESJWRM Version 2.0 Average Annual Diversion*** (acre-feet)	PCBL Version 2.0 Average Annual Diversion*** (acre-feet)	Data Source
					RL*	NL**	Delivery			
26	Stanislaus River at Goodwin Dam to Farmington Flood Control Basin via Little Johns Creek and Lower Farmington Canal to Central San Joaquin WCD for Ag	Import (outside of ESJWRM)	Central San Joaquin WCD	Ag	15%	2%	83%	30,000	24,300	SEWD
27	Stanislaus River to Farmington Groundwater Recharge Program	Import (outside of ESJWRM)	Farmington Groundwater Recharge Program	Recharge	100%	0%	0%	3,300	4,900	SEWD
28	Stanislaus River at Goodwin Dam to Oakdale ID North for Ag	Import (outside of ESJWRM)	Export out of model (imported in Diversions 52, 55, and 57)	Ag	0%	0%	0%	98,800	88,000	OID
29	Stanislaus River at Goodwin Dam to Oakdale ID South for Ag [Modesto Subbasin]	Import (outside of ESJWRM)	Export out of model (imported in Diversions 53, 54, 56, and 58)	Ag	0%	0%	0%	136,400	121,500	OID
30	Stanislaus River to Woodward Reservoir to South San Joaquin ID for Ag	Import (outside of ESJWRM)	Export out of model (imported in Diversions 59, 60, and 61)	Ag	0%	0%	0%	189,500	150,000	SSJID

ID	Description	Diversion Location	Delivery Area	Primary Use	Fraction			ESJWRM Version 2.0 Average Annual Diversion*** (acre-feet)	PCBL Version 2.0 Average Annual Diversion*** (acre-feet)	Data Source
					RL*	NL**	Delivery			
31	Stanislaus River to Woodward Reservoir to South San Joaquin ID Division 6 for Ag	Import (outside of ESJWRM)	Export out of model (imported in Diversions 59, 60, and 61)	Ag	0%	0%	0%	5,200	7,000	SSJID
32	Woodward Reservoir Seepage	Import (outside of ESJWRM)	Woodward Reservoir	Recharge	100%	0%	0%	17,100	16,000	SSJID
33	Stanislaus River to Woodward Reservoir to Nick C. DeGroot WTP to City of Manteca for M&I	Import (outside of ESJWRM)	City of Manteca	Urban	0%	0%	100%	6,800	10,700	UWMP
34	Stanislaus River to Woodward Reservoir to Nick C. DeGroot WTP to City of Escalon for M&I	Import (outside of ESJWRM)	City of Escalon	Urban	0%	0%	100%	0	0	UWMP
35	Stanislaus River to Woodward Reservoir to Nick C. DeGroot WTP to City of Lathrop for M&I [Tracy Subbasin]	Import (outside of ESJWRM)	City of Lathrop	Urban	0%	0%	100%	1,400	6,300	UWMP
36	Stanislaus River to Woodward Reservoir to Nick C. DeGroot WTP to City of Ripon for M&I	Import (outside of ESJWRM)	City of Ripon	Urban	0%	0%	100%	0	0	UWMP

ID	Description	Diversion Location	Delivery Area	Primary Use	Fraction			ESJWRM Version 2.0 Average Annual Diversion*** (acre-feet)	PCBL Version 2.0 Average Annual Diversion*** (acre-feet)	Data Source
					RL*	NL**	Delivery			
37	Tuolumne River to Modesto ID for Ag [Modesto Subbasin]	Import (outside of ESJWRM)	Modesto ID	Ag	3%	19%	78%	232,500	196,000	Stanislaus River Basin Plan ESJWRM Update
38	Tuolumne River to City of Modesto (via Modesto ID) for M&I [Modesto Subbasin]	Import (outside of ESJWRM)	Element group representing City of Modesto	Urban	3%	1%	96%	30,700	27,100	Stanislaus River Basin Plan ESJWRM Update
39	Cosumnes River to Riparian for Ag [Cosumnes Subbasin]	Cosumnes River	Riparian diverters along river	Ag	10%	2%	88%	2,800	2,300	C2VSim
40	Dry Creek to Riparian for Ag [Split Across Subbasins]	Dry Creek	Riparian diverters along river	Ag	10%	2%	88%	5,600	6,400	C2VSim
41	Mokelumne River to Riparian for Ag	Mokelumne River	Riparian diverters along river	Ag	10%	2%	88%	9,600	11,300	C2VSim
42	Calaveras River to Riparian for Ag	Calaveras River	Riparian diverters along river	Ag	10%	2%	88%	11,400	10,900	C2VSim
43	Stanislaus River to Riparian for Ag [Split Across Subbasins]	Stanislaus River	Riparian diverters along river	Ag	15%	3%	82%	30,600	30,400	C2VSim
44	Tuolumne River to Riparian for Ag [Modesto Subbasin]	Tuolumne River	Riparian diverters along river	Ag	15%	3%	82%	6,100	6,300	C2VSim

ID	Description	Diversion Location	Delivery Area	Primary Use	Fraction			ESJWRM Version 2.0 Average Annual Diversion*** (acre-feet)	PCBL Version 2.0 Average Annual Diversion*** (acre-feet)	Data Source
					RL*	NL**	Delivery			
45	San Joaquin River to Riparian for Ag [Split Across Subbasins]	San Joaquin River	Riparian diverters along river	Ag	15%	3%	82%	5,800	5,900	C2VSim
46	Modesto ID Groundwater Pumping Deliveries [Modesto Subbasin]	Import (outside of ESJWRM)	Modesto ID	Ag	0%	0%	100%	21,500	24,300	Stanislaus River Basin Plan ESJWRM Update
47	Tuolumne River to Modesto Reservoir Seepage [Modesto Subbasin]	Import (outside of ESJWRM)	Modesto Reservoir	Recharge	100%	0%	0%	23,000	23,000	Stanislaus River Basin Plan ESJWRM Update
48	City of Modesto GW Pumping Deliveries [Modesto Subbasin]	Import (outside of ESJWRM)	City of Modesto	Urban	3%	1%	96%	33,100	32,200	Stanislaus River Basin Plan ESJWRM Update
49	City of Oakdale GW Pumping Deliveries [Modesto Subbasin]	Import (outside of ESJWRM)	City of Oakdale	Urban	3%	1%	96%	4,600	4,800	Stanislaus River Basin Plan ESJWRM Update
50	City of Waterford GW Pumping Deliveries [Modesto Subbasin]	Import (outside of ESJWRM)	City of Waterford	Urban	3%	1%	96%	1,700	1,500	Stanislaus River Basin Plan ESJWRM Update

ID	Description	Diversion Location	Delivery Area	Primary Use	Fraction			ESJWRM Version 2.0 Average Annual Diversion*** (acre-feet)	PCBL Version 2.0 Average Annual Diversion*** (acre-feet)	Data Source
					RL*	NL**	Delivery			
51	City of Riverbank GW Pumping Deliveries [Modesto Subbasin]	Import (outside of ESJWRM)	City of Riverbank	Urban	3%	1%	96%	4,500	4,400	Stanislaus River Basin Plan ESJWRM Update
52	Farm Deliveries to Oakdale ID North for Ag	Import (exported in Diversion 28)	Oakdale ID in ESJ Subbasin	Ag	0%	0%	100%	78,900	75,100	OID AWMP
53	Farm Deliveries to Oakdale ID South for Ag [Modesto Subbasin]	Import (exported in Diversion 29)	Oakdale ID in Modesto Subbasin	Ag	0%	0%	100%	121,000	114,400	OID AWMP
54	Recycled Water to Oakdale ID South for Ag [Modesto Subbasin]	Import (exported in Diversion 29)	Oakdale ID in Modesto Subbasin	Ag	0%	0%	100%	3,300	3,300	OID AWMP
55	Deliveries to Annual Contracts by Oakdale ID North for Ag	Import (exported in Diversion 28)	Oakdale ID in ESJ Subbasin	Ag	0%	0%	100%	2,100	2,600	OID AWMP
56	Deliveries to Annual Contracts by Oakdale ID South for Ag [Modesto Subbasin]	Import (exported in Diversion 29)	Oakdale ID in Modesto Subbasin	Ag	0%	0%	100%	2,300	2,500	OID AWMP
57	Canal and Drain Seepage in Oakdale ID North	Import (exported in Diversion 28)	Oakdale ID in ESJ Subbasin	Recharge	100%	0%	0%	17,800	17,500	OID AWMP

ID	Description	Diversion Location	Delivery Area	Primary Use	Fraction			ESJWRM Version 2.0 Average Annual Diversion*** (acre-feet)	PCBL Version 2.0 Average Annual Diversion*** (acre-feet)	Data Source
					RL*	NL**	Delivery			
58	Canal and Drain Seepage in Oakdale ID South [Modesto Subbasin]	Import (exported in Diversion 29)	Oakdale ID in Modesto Subbasin	Recharge	100%	0%	0%	18,300	18,000	OID AWMP
59	Farm Deliveries to South San Joaquin ID for Ag	Import (exported in Diversions 30 and 31)	South San Joaquin ID	Ag	0%	0%	100%	144,000	120,000	SSJID AWMP
60	Direct Diversion from Main Distributary Canal to South San Joaquin ID for Ag	Import (exported in Diversions 30 and 31)	South San Joaquin ID	Ag	0%	0%	100%	1,400	0	SSJID AWMP
61	Main Distributary Canal and Lateral Seepage in South San Joaquin ID	Import (exported in Diversions 30 and 31)	South San Joaquin ID	Recharge	90%	10%	0%	33,200	28,200	SSJID AWMP

*RL = Recoverable Loss (canal seepage or recharge)

**NL = Non-Recoverable Loss (evaporation)

*** Averages calculated only for years with diversions occurring (i.e., non-zero average)

1.1.10 Groundwater Pumping

Groundwater pumping within ESJWRM is separated into well- or element-based pumping. The former largely includes district-operated wells that feed into the surface water supply network, while the latter includes estimated private groundwater pumping.

Updates to ESJWRM Version 2.0 for well pumping was the addition of Modesto Subbasin wells included in the model updates made for the Stanislaus River Basin Plan and the addition of two OID wells. OID and SSJID district wells were updated to export water out of the model since the district groundwater pumping is included in the farm deliveries to SSJID, OID North, and OID South included as surface water deliveries. Additionally, all groundwater pumping delivery groups were reviewed and updated to reflect a more recent understanding of Subbasin operations. Table 3 lists the number of wells by type and agency included in ESJWRM.

Element pumping is estimated by IWFM within the model simulation. Element pumping in ESJWRM Version 2.0 was updated to remove all model-calculated groundwater pumping for urban uses in urban areas.

Table 3: Summary of ESJWRM Well Pumping

Agency	Number of Urban Pumping Wells	Number of Agricultural Pumping Wells	Average Annual Urban Pumping (acre-feet)	Average Annual Agricultural Pumping (acre-feet)
Cal Water	56	---	8,200	0
Escalon	4	---	1,400	0
Lathrop	6	---	2,200	0
Linden County WD	4	---	440	0
Lockeford CSD	4	---	510	0
Lodi	29	---	13,600	0
Manteca	15	31	9,300	1,300
Oakdale ID*	---	26	0	6,700
Ripon	9	9	3,900	1,000
SEWD	5	---	590**	0
SSJID	---	28	0	5,200
Stockton	37	---	8,500	0
Other Modesto Subbasin Wells	---	246	0	68,000
Total Average Annual Pumping (acre-feet)			48,640	82,200

* Includes wells located both in ESJ Subbasin and Modesto Subbasin

** Average only when wells were active (WY 2015-2020)

1.1.11 Agricultural Operations

Factors that apply to the agricultural operations represented in the model include agricultural return flow fractions, agricultural reuse fractions, and target soil moisture content.

Both SSJID and OID report large amounts of tailwater as outflow from the districts' drainage systems in their respective AWMPs (SSJID, 2021) (OID, 2021). For OID, the amount of tailwater from the district lands is represented through adjustments to the return flow fraction, which controls how much of applied water ultimately ends up as drainage to model stream nodes. For SSJID, since the majority of the tailwater ends up back in Stanislaus River the reported system outflows are included as a stream inflow to Stanislaus River below SSJID. The return flow fraction was likewise adjusted for SSJID's area.

The reuse fraction is the percent of applied water that can be reused as irrigation to meet demand. Based on analysis of the OID 2020 AWMP (OID, 2021), the reuse fraction for OID model elements was set to 2%.

The target soil moisture specifies the fraction of field capacity that IWFM will iterate to and was utilized to adjust OID demand, first in the adjusted version of ESJWRM Version 1.1 prepared for the Stanislaus River Basin Plan and then adjusted based on analysis of the OID 2020 AWMP (OID, 2021).

Canal and drain seepage for the agricultural agencies is included in surface water diversion information and discussed in Section 1.1.9 above. For agencies that may have surface water agreements where a portion of the delivery losses is assumed to occur in the river (e.g., NSJWCD), the interaction between the stream and the groundwater system is simulated separately in ESJWRM and assumed to account for the conveyance losses. This is considered a special case in the operational water budget discussed in Section **Error! Reference source not found.**.

All other files that control agricultural operations were extended through water year 2020 by repeating the recent historical data.

1.2 Calibration Updates and Results

The goals of model calibration are (1) to achieve a reasonable water budget for each component of the hydrologic cycle modeled (i.e., land and water use, soil moisture, stream flow, and groundwater) and (2) to maximize the agreement between simulated and observed groundwater levels at selected well locations and simulated and observed streamflow hydrographs at selected gaging stations. These objectives are achieved through verification of the model input data and adjustment of model parameters.

Due to uncertainty in the model initial conditions, a one year "ramp up" period is included to allow groundwater levels to stabilize. Thus, the model calibration period for the ESJWRM is October 1995 through September 2020 or water years 1996 through 2020 (25 years).

1.2.1 Calibration Process

Model calibration begins after data analysis and input data file development is completed. The calibration effort can be broken down into subsets that align with packages within the IWFM platform. As an integrated groundwater model, the results of each part of the simulation are dependent on one another. The model calibration can be considered a systematic process that includes the following activities:

- Collect data and set calibration targets
- Calibrate land and water use
- Calibrate groundwater system
- Calibrate stream system
- Refine groundwater level calibration using PEST

- Perform sensitivity analysis
- Conduct additional refinements to model as necessary

1.2.1.1 Agricultural Demand Calibration

As part of the calibration of the land and water use budget, root zone parameters are adjusted as needed to achieve reasonable estimates of agricultural demand and to develop the components of a balanced root zone budget. Demand calibration serves as the foundation of the IWFM calibration for agricultural areas, as demand estimated often translates directly to groundwater pumping, which is the primary stress on the groundwater system. To adjust agricultural demand, element-level root zone parameters, particularly the soil hydraulic conductivity, were adjusted in accordance with the hydrologic soil group and area of the model. Soil hydraulic conductivity was adjusted in the areas of the model representing OID North, NSJWCD, and SSJID to better match reported groundwater pumping, demand, and per unit water use.

During agricultural demand calibration, also called root zone calibration, the curve numbers assigned to different land uses were also reviewed. Based on review of percolation of precipitation occurring in different areas of the model, the curve numbers for native and riparian land uses were adjusted. Additionally, refinements were made to the unsaturated zone initial soil moisture to standardize the amount of water in the unsaturated zone from year to year.

1.2.1.2 PEST-Assisted Aquifer Calibration

Aquifer parameter calibration of ESJWRM utilized a parametric grid covering the model area that reflected the scale at which parameters were adjusted throughout the calibration process. The parametric grid, originally adopted from DWR's California Central Valley Groundwater-Surface Water Simulation Model with coarse grid (C2VSimCG) nodes, was slightly modified to cover the entire ESJWRM model along the boundaries and additional nodes were added or moved within areas of the model to provide better control. Aquifer parameters included in ESJWRM are horizontal hydraulic conductivity, vertical hydraulic conductivity, specific storage, and specific yield.

Due to the complexities of calibrating an integrated water resources model, a hybrid approach for calibration was utilized to perform a manual calibration on initial water budgets and regional groundwater conditions and a PEST-assisted calibration using PEST (Doherty, 2015) to achieve a refinement of the calibrated parameters that would result in a more accurate simulation. The use of the PEST software package is discussed further in Section 1.2.2.2.

1.2.2 Calibration Verification

ESJWRM was calibrated to local data and information, surface water flows, groundwater hydrographs, and groundwater contours. The sources used to check model results include local knowledge (mainly gathered during TAC meetings), agricultural water management plans, urban water management plans, other local planning efforts, measured groundwater levels, and observed streamflow data.

1.2.2.1 Streamflow Calibration

Streamflow calibration is primarily performed by comparing the simulated streamflow with local observation data for 11 stream gages located on major streams. Data for these gages came from USGS, USACE, or the California Data Exchange Center (CDEC). Two of these stream gages (Mokelumne River below Camanche